Operations and Monitoring

4

In This Chapter.... page

Introduction

The previous material in Chapter 3 gave a reference listing of all the programmable functions of the inverter. We suggest that you first scan through the listing of inverter functions to gain a general familiarity. This chapter will build on that knowledge in the following ways:

1. **Related functions** – Some parameters interact with or depend on the settings in other functions. This chapter lists “required settings” for a programmable function to serve as a cross-reference and an aid in showing how functions interact.
2. **Intelligent terminals** – Some functions rely on an input signal from control logic terminals or generate output signals in other cases.
3. **Electrical interfaces** – This chapter shows how to make connections between the inverter and other electrical devices.
4. **Auto-tuning** – The SJ300 inverter has the ability to run a calibration procedure in which it takes measurements of the motor’s electrical characteristics. This chapter shows how to run the auto-tuning procedure to help the inverter run the motor more smoothly and efficiently.
5. **PID Loop Operation** – The SJ300 has a built-in PID loop that calculates the optimal inverter output frequency to control an external process. This chapter shows the parameters and input/output terminals associated with PID loop operation.
6. **Multiple motors** – A single SJ300 inverter may be used with two or more motors in some types of applications. This chapter shows the electrical connections and inverter parameters involved in multiple-motor applications.

The topics in this chapter can help you decide the features that are important to your application, and how to use them. The basic installation covered in Chapter 2 concluded with the powerup test and running the motor. Now, this chapter starts from that point and shows how to make the inverter part of a larger control or automation system.

Cautions for Operating Procedures

Before continuing, please read the following Caution messages.

CAUTION: The heat sink fins will have a high temperature. Be careful not to touch them. Otherwise, there is the danger of getting burned.

CAUTION: The operation of the inverter can be easily changed from low speed to high speed. Be sure check the capability and limitations of the motor and machine before operating the inverter. Otherwise, it may cause injury to personnel.

CAUTION: If you operate a motor at a frequency higher than the inverter standard default setting (50Hz/60Hz), be sure to check the motor and machine specifications with the respective manufacturer. Only operate the motor at elevated frequencies after getting their approval. Otherwise, there is the danger of equipment damage.

Warnings for Operating Procedures

Before continuing, please read the following Warning messages.

WARNING: Be sure to turn ON the input power supply only after closing the front case. While the inverter is energized, be sure not to open the front case. Otherwise, there is the danger of electric shock.

WARNING: Be sure not to operate electrical equipment with wet hands. Otherwise, there is the danger of electric shock.

WARNING: While the inverter is energized, be sure not to touch the inverter terminals even when the motor is stopped. Otherwise, there is the danger of electric shock.

WARNING: If the Retry Mode is selected, the motor may suddenly restart after a trip stop. Be sure to stop the inverter before approaching the machine (be sure to design the machine so that safety for personnel is secure even if it restarts.) Otherwise, it may cause injury to personnel.

WARNING: If the power supply is cut OFF for a short period of time, the inverter may restart operation after the power supply recovers if the Run command is active. If a restart may pose danger to personnel, so be sure to use a lock-out circuit so that it will not restart after power recovery. Otherwise, it may cause injury to personnel.

WARNING: The Stop Key is effective only when the Stop function is enabled. Be sure to enable the Stop Key separately from the emergency stop. Otherwise, it may cause injury to personnel.

WARNING: During a trip event, if the alarm reset is applied and the Run command is present, the inverter will automatically restart. Be sure to apply the alarm reset only after verifying the Run command is OFF. Otherwise, it may cause injury to personnel.

WARNING: Be sure not to touch the inside of the energized inverter or to put any conductive object into it. Otherwise, there is a danger of electric shock and/or fire.

WARNING: If power is turned ON when the Run command is already active, the motor will automatically start and injury may result. Before turning ON the power, confirm that the RUN command is not present.

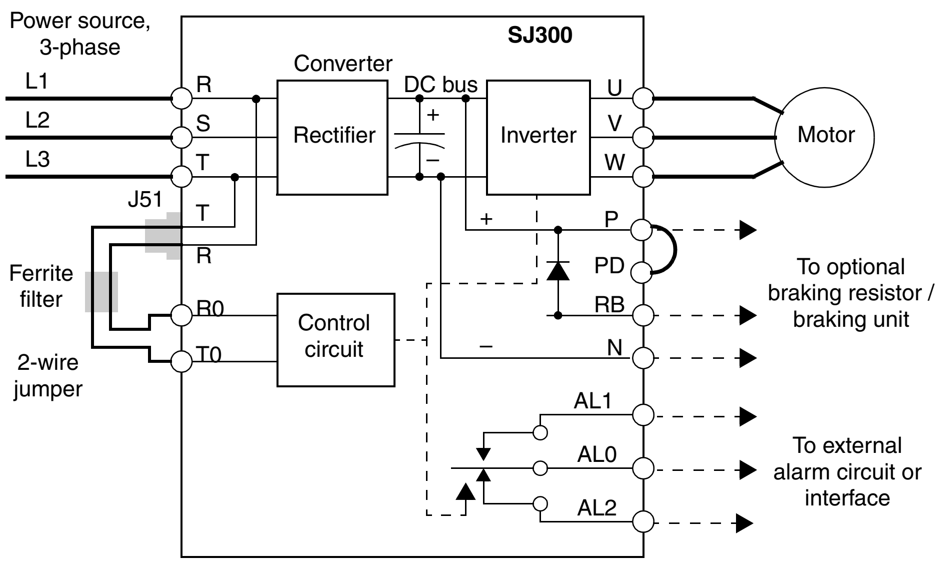
WARNING: When the Stop key function is disabled, pressing the Stop key does not stop the inverter, nor will it reset a trip alarm.

WARNING: Be sure to provide a separate, hard-wired emergency stop switch when the application warrants it.

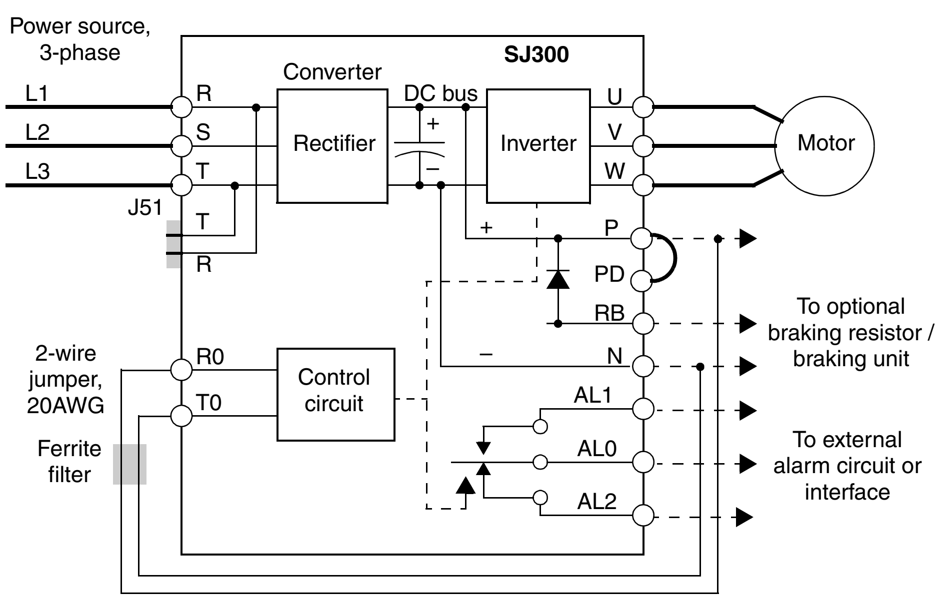
Optional Controlled Decel and Alarm at Power Loss

With the default SJ300 inverter configuration, a sudden power loss will cause the inverter to shut down immediately. If running at the time, the motor and load will coast to a stop. And without power, the inverter's alarm output will not activate. This default performance may be fine for applications with loads such as fans and pumps. However, some loads may require controlled decelerations upon power loss, or you may want an alarm signal upon power loss. This section describes how to harness regenerative energy so that the motor/load actually powers the inverter long enough to control a final deceleration and power the alarm output.

The diagram below shows the default configuration. Chapter 2 covered wiring the power source to the inverter input and the inverter output to the motor. By default, the inverter's internal control circuit gets its power from two phases (R and T) from the input. The user-accessible 2-wire jumper (R–R0 and T–T0) connects input power to the control circuit.



To provide power to the control circuit after input power loss, you must change the control circuit wiring as shown below (steps provided on following page).



Follow the steps to implement the wiring change shown in the previous diagram.

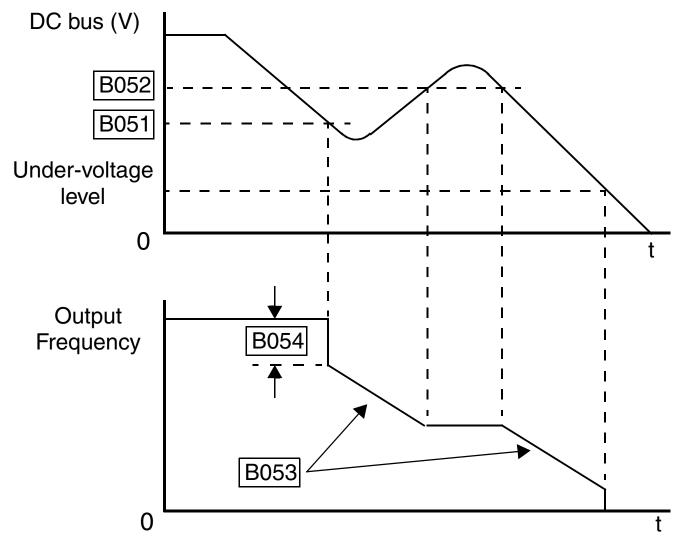
1. Remove the 2-wire jumper J51 (terminals [R0] and [T0] to connector J51).
2. Procure several inches of multi-strand 20 AWG (0.5mm^2) or slightly heavier wire.
3. Connect a wire to terminal [R0] that is long enough to connect to terminal [P] (do not connect to [P] yet).
4. Connect a wire to terminal [T0] that is long enough to connect to terminal [N] (do not connect to [N] yet).
5. Remove the ferrite filter from the original jumper wire and then slide it onto the new wires connecting to terminals [R0] and [T0]. (Be sure to save the original jumper in a safe place.)
6. Connect the wire from [R0] to [P], and connect the wire from [T0] to [N] as shown.

More information on power loss related alarm functions, see "Instantaneous Power Failure / Under-voltage Signal" on page 4–51.

The following table lists the functions related to the controlled deceleration at power loss feature. After making the wiring change, use function B050 to enable the feature. Use B051 to determine the point at which a decaying DC bus voltage will trigger the controlled deceleration. Use parameter B054 to specify an initial step-wise deceleration at power loss, and B053 to specify the duration of the linear deceleration. Note that this feature also affects the output signals that indicate instantaneous power fail and under-voltage conditions (see "Instantaneous Power Failure / Under-voltage Signal" on page 4–51).

Func. Code	Name	Description	Range
B050	Controlled deceleration and stop on power loss	Allows inverter control using regenerative energy to decelerate after loss of input power (requires jumper change)	Two option codes: 00Disable 01Enable
B051	DC bus voltage trigger level during power loss	Sets trigger for controlled deceleration and stop on power loss function	0.0 to 1000.V
B052	Over-voltage threshold during power loss	Sets over-voltage threshold for controlled deceleration function	0.0 to 1000.V
B053	Deceleration time setting during power loss	Deceleration time inverter uses only at power loss	0.01 to 99.99 sec. / 100.0 to 999.9 sec. / 1000 to 3600 sec.
B054	Initial output frequency decrease during power loss	Sets the initial decrease in output frequency upon power loss	0.00 to 10.00 Hz

The timing diagram below shows a power loss scenario and the related parameter settings. During the controlled deceleration the inverter itself acts as a load to decelerate the motor. With either a high-inertia load or a short deceleration time (or both), it is possible that the inverter impedance will not be low enough to continue linear deceleration and avoid an over-voltage condition on the DC bus. Use parameter B052 to specify a threshold for the over-voltage. In this case, the inverter pauses deceleration (runs at constant speed). When the DC bus decays again below the threshold, linear deceleration resumes. The pause/resume process will repeat as necessary until the DC bus energy is depleted (under-voltage condition occurs).



NOTE: (1) Be sure to set the *over-voltage threshold* greater than the *DC bus voltage trigger level* (B052 > B051) for proper operation.
(2) Once the power loss deceleration function starts, it will complete and stop the motor even if input power is restored. In that case, it automatically enables the Run mode again.

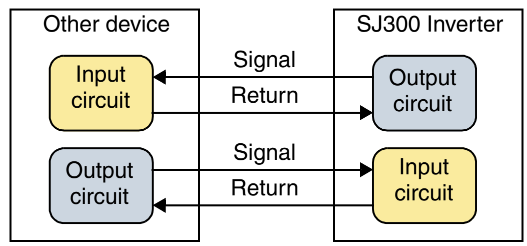
Connecting to PLCs and Other Devices

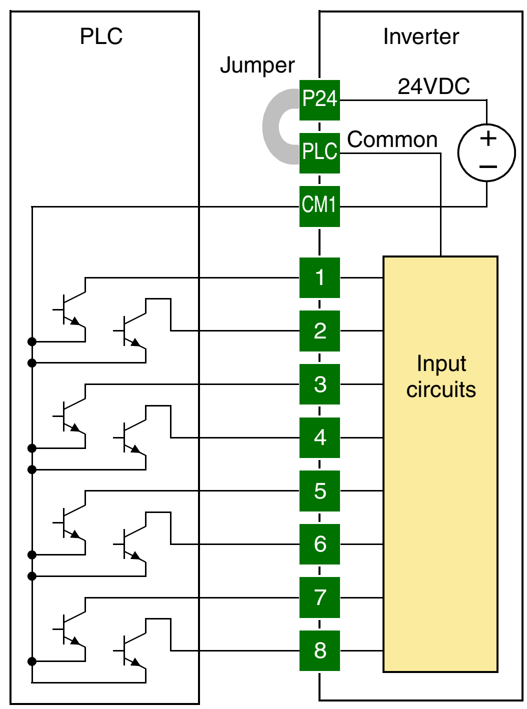
Hitachi inverters (drives) are useful in many types of applications. During installation, the inverter keypad (or other programming device) will facilitate the initial configuration. After installation, the inverter will generally receive its control commands through the control logic terminals or serial interface from another controlling device. In a simple application such as single-conveyor speed control, a Run/Stop switch and potentiometer will give the operator all the required control. In a sophisticated application, you may have a *programmable logic controller* (PLC) as the system controller with several connections to the inverter.

It is not possible to cover all the possible types of application in this manual. It will be necessary for you to know the electrical characteristics of the devices you want to connect to the inverter. Then, this section and the following sections on I/O terminal functions can help you quickly and safely connect those devices to the inverter.

CAUTION: It is possible to damage the inverter or other devices if your application exceeds the maximum current or voltage characteristics of a connection point.

The connections between the inverter and other devices rely on the electrical input/output characteristics at both ends of each connection, shown in the diagram to the right. The inverter can accept either sourcing or sinking type inputs from an external device (such as a PLC). A terminal jumper configures the input type, connecting the input circuit *common* to the supply (+) or (–). Detailed wiring examples are in "Using Intelligent Input Terminals" on page 4–11. This chapter shows the inverter's internal electrical component(s) at each I/O terminal and how to interface them with external circuits.





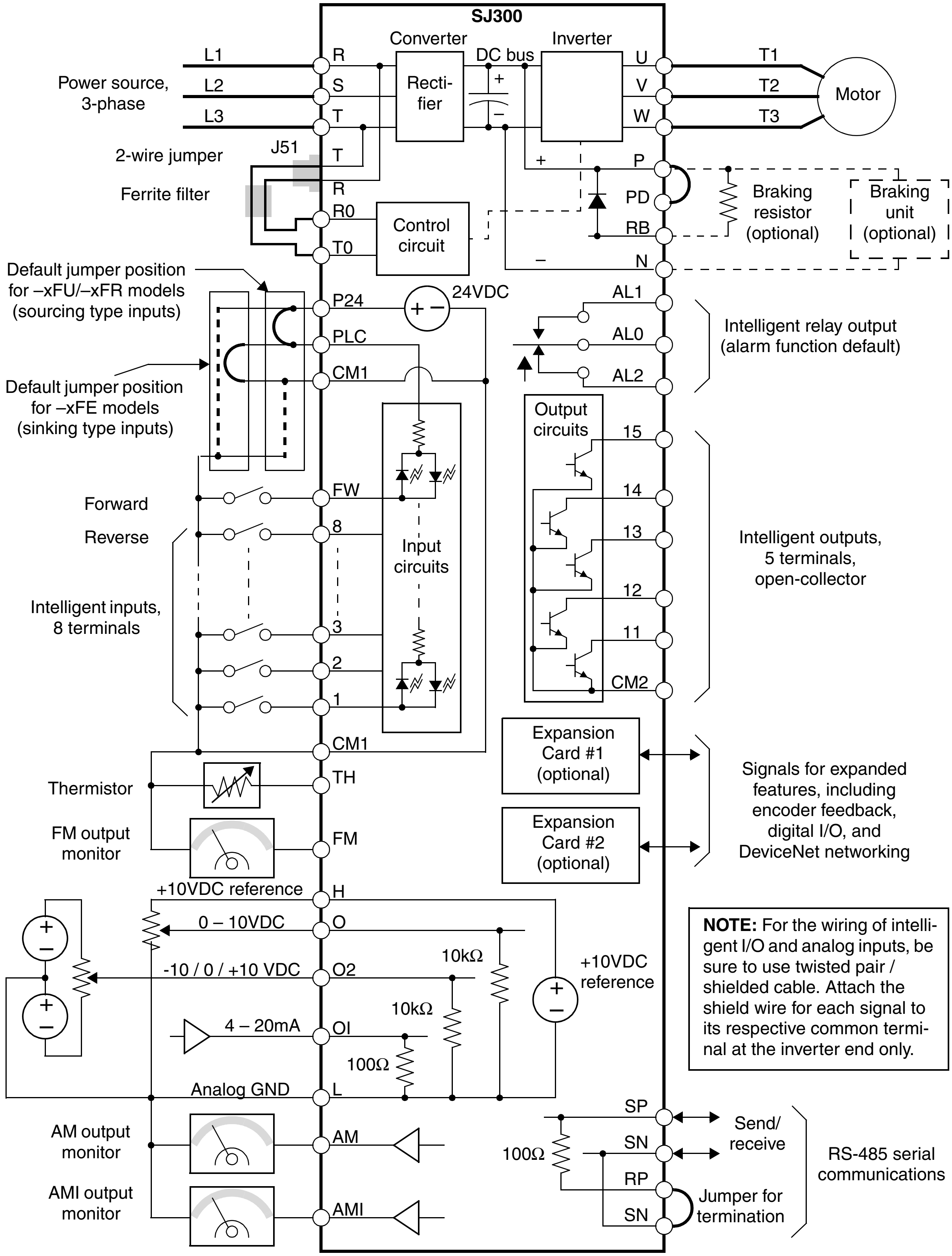
In order to avoid equipment damage and get your application running smoothly, we recommend drawing a schematic of each connection between the inverter and the other device. Include the internal components of each device in the schematic, so that it makes a complete circuit loop.

After making the schematic, then:

1. Verify that the current and voltage for each connection is within the operating limits of each device.
2. Make sure that the logic sense (active high or active low) of any ON/OFF connection is correct.
3. Verify inputs are configured correctly (sink/source) to interface to interface to any external devices (PLCs, etc.).
4. Check the zero and span (curve end points) for analog connections, and be sure the scale factor from input to output is correct.
5. Understand what will happen at the system level if any particular device suddenly loses power, or powers up after other devices.

Example Wiring Diagram

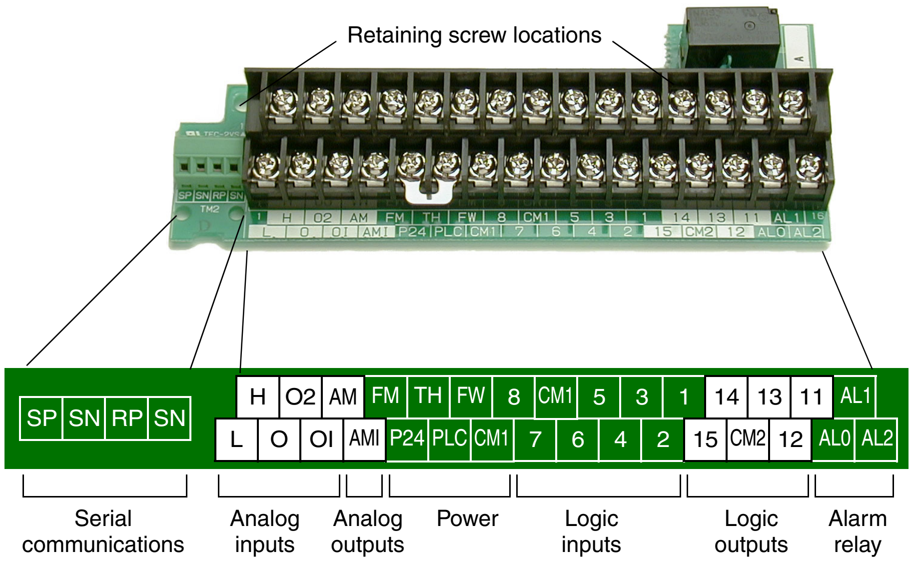
The schematic diagram below provides a general example of logic connector wiring, in addition to basic power and motor wiring covered in Chapter 2. The goal of this chapter is to help you determine the proper connections for the various terminals shown below for your specific application needs.



NOTE: For the wiring of intelligent I/O and analog inputs, be sure to use twisted pair / shielded cable. Attach the shield wire for each signal to its respective common terminal at the inverter end only.

Specifications of Control and Logic Connections

The control logic connector board is removable for wiring convenience, as shown below (first, remove two retaining screws). The small connector to the left is for serial communications.



Specifications for the logic connection terminals are in the following table:

Terminal Name	Description	Ratings and Notes
[P24]	+24V power for inputs	24VDC supply, 100 mA max.
[CM1]	+24V common	Common for 24V supply, [FW], [TH], inputs [1] to [8], and [FM]. (Note: Do not ground)
[PLC]	Common for logic inputs	Common for input terminals [1] to [8], jumper to CM1 for sinking, jumper to P24 for sourcing
[CM2]	Common for logic outputs	Common for output terminals [11] to [15]
[1], [2], [3], [4], [5], [6], [7], [8]	Intelligent (programmable) discrete logic inputs	27VDC max. (use [P24] or an external supply referenced to terminal [CM1]), 4.7kΩ input impedance
[FW]	Forward/stop command	27VDC max. (use [P24] or an external supply referenced to terminal [CM1]), 4.7kΩ input impedance
[11], [12], [13], [14], [15]	Intelligent (programmable) discrete logic outputs	Open collector type, 50mA max. ON state current, 27 VDC maximum OFF state voltage
[TH]	Thermistor input	Reference to [CM1], min. thermistor power 100mW
[FM]	PWM output	0 to 10VDC, 1.2 mA max., 50% duty cycle
[AM]	Voltage analog output	0 to 10VDC, 2 mA max.
[AMI]	Current analog output	4-20 mA, nominal load impedance 250Ω
[L]	Common for analog inputs	Sum of [OI], [O], and [H] currents (return)
[OI]	Analog input, current	4 to 19.6 mA range, 20 mA nominal
[O]	Analog input, voltage	0 to 9.6 VDC range, 10VDC nominal, 12VDC max., input impedance 10 kΩ
[H]	+10V analog reference	10VDC nominal, 10 mA max.
[AL0]	Relay common contact	Contacts AL0–AL1, maximum loads: 250VAC, 2A; 30VDC, 8A resistive load 250VAC, 0.2A; 30VDC, 0.6A inductive load Contacts AL0–AL2, maximum loads: 250VAC, 1A; 30VDC 1A max. resistive load 250VAC, 0.2A; 30VDC, 0.2A max. inductive load Min. loads: 100 VAC, 10mA; 5VDC, 100mA
[AL1]	Relay contact, normally closed during RUN	
[AL2]	Relay contact, normally open during RUN	

Terminal Listing

Use the following table to locate pages for intelligent input and output material in this chapter.

Intelligent INPUTS				Intelligent OUTPUTS			
Symbol	**Code**	**Name**	**Page**	**Symbol**	**Code**	**Name**	**Page**
RV	01	Reverse Run/Stop	4–12	RUN	00	Run signal	4–43
CF1	02	Multi-speed select, Bit 0 (LSB)	4–13	FA1	01	Freq. arrival type 1 – constant speed	4–44
CF2	03	Multi-speed select, Bit 1	4–13				
CF3	04	Multi-speed select, Bit 2	4–13	FA2	02	Freq. arrival type 2 – over-frequency	4–44
CF4	05	Multi-speed select, Bit 3 (LSB)	4–13				
JG	06	Jogging	4–16	OL	03	Overload advance notice signal	4–46
DB	07	External DC braking	4–17	OD	04	Output deviation for PID control	4–47
SET	08	Set (select) second motor data	4–18	AL	05	Alarm signal	4–48
2CH	09	2-stage accel and decel	4–19	FA3	06	Freq. arrival type 3 – at freq.	4–44
FRS	11	Free-run stop	4–20	OTQ	07	Over-torque signal	4–50
EXT	12	External trip	4–21	IP	08	Instantaneous power failure signal	4–51
USP	13	Unattended start protection	4–22	UV	09	Under-voltage signal	4–51
CS	14	Commercial power source	4–23	TRQ	10	In torque limit signal	4–54
SFT	15	Software lock	4–25	RNT	11	Run time over	4–54
AT	16	Analog input voltage/current sel.	4–26	ONT	12	Power-ON time over	4–54
SET3	17	Set (select) 3rd motor data	4–18	THM	13	Thermal alarm signal	4–55
RS	18	Reset inverter	4–27	BRK	19	Brake release signal	4–58
STA	20	Start (3-wire interface)	4–29	BER	20	Brake error signal	4–58
STP	21	Stop (3-wire interface)	4–29	ZS	21	Zero speed detect	4–58
F/R	22	FW, RV (3-wire interface)	4–29	DSE	22	Speed deviation maximum	4–58
PID	23	PID ON/OFF	4–30	POK	23	Positioning completion	4–58
PIDC	24	PID Reset	4–30	FA4	24	Freq. arrival type 4 – over-frequency (2)	4–44
CAS	26	Control gain setting	4–31				
UP	27	Remote control Up func.	4–33	FA5	25	Freq. arrival type 5 – at frequency (2)	4–44
DWN	28	Remote control Down func.	4–33				
UDC	29	Remote control data clearing	4–33	OL2	26	Overload advance notice signal (2)	4–46
OPE	31	Operator control	4–34				
SF1–7	32–38	Multi-speed bits 1 to 7	4–13				
OLR	39	Overload restriction	4–35				
TL	40	Torque limit enable	4–37				
TRQ1	41	Torque limit select, bit 1 (LSB)	4–37				
TRQ2	42	Torque limit select, bit 2 (MSB)	4–37				
PPI	43	P / PI mode selection	4–31				
BOK	44	Brake confirmation signal	4–39				
ORT	45	Orientation (home search)	4–41				
LAC	46	LAC: LAD cancel	4–41				
PCLR	47	Position deviation reset	4–41				
STAT	48	Pulse train position cmd enable	4–41				

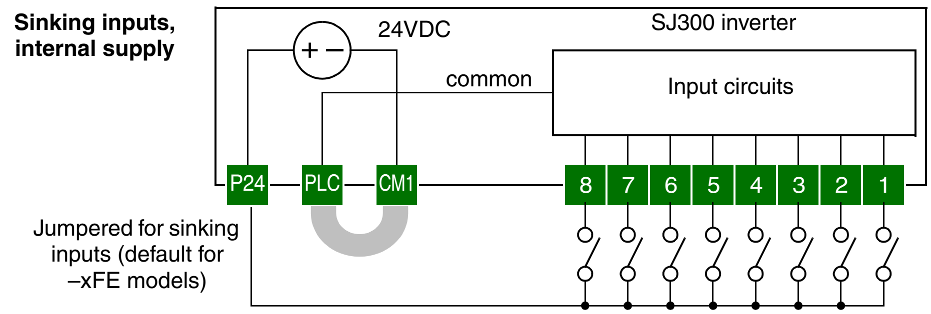
Using Intelligent Input Terminals

Intelligent terminals [1], [2], [3], [4], [5], [6], [7], and [8] are identical, programmable inputs for general use. The input circuits can use the inverter's internal (isolated) +24V field supply (P24) to power the inputs. The input circuits connect internally to [PLC] as a common point. To use the internal supply to power the inputs, use the jumper as shown. Remove the jumper to use an external supply, or to interface to a PLC system (or other) that has solid state outputs. If you use an external supply or PLC system, its power return must connect to the [PLC] terminal on the inverter to complete the input circuit.

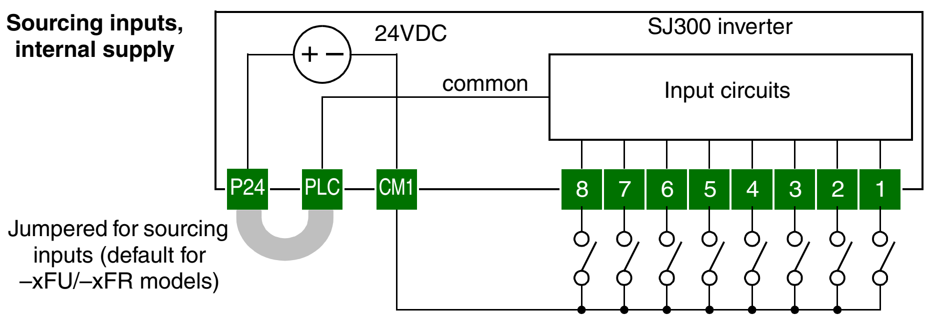
Input Wiring Examples

The following four input configurations are available to interface the inverter inputs to switches or the outputs of another system, such as a PLC.

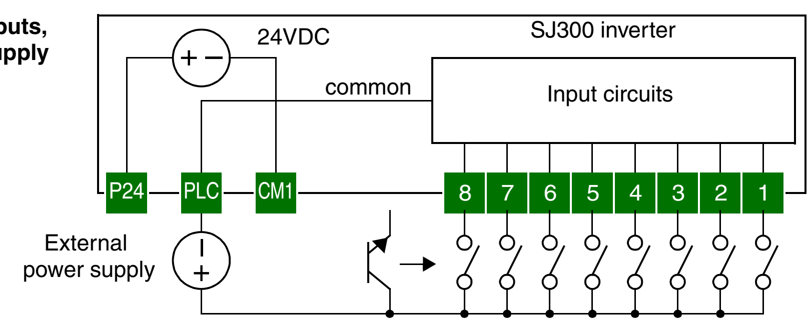
Sinking inputs, internal supply



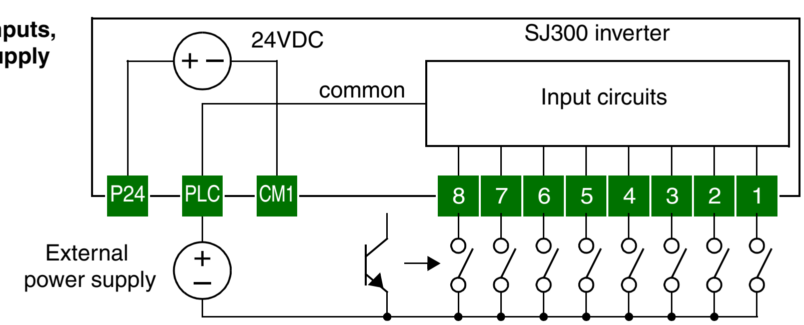
Sourcing inputs, internal supply



Sinking inputs, external supply



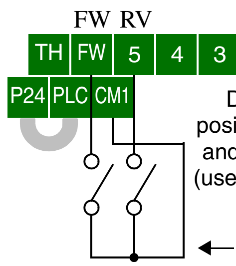
Sourcing inputs, external supply



Wiring Diagram Conventions

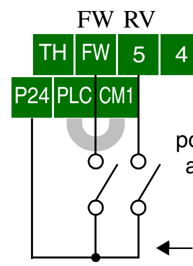
The input wiring diagrams in this chapter are examples only. Default and non-default input terminal assignments are noted throughout; your particular assignments may be different. The wiring diagrams show the –xFU/–xFR model default [P24]–[PLC] jumper position (U.S./Jpn versions), as shown below on the left. The common (return) for inputs is [CM1] in this case. The diagram on the right shows the default jumper position and example input wiring for –xFE models (Europe version). For this case, the common (return) for inputs is [P24]. **Be sure the jumper position and return terminal used match your application wiring needs.**

–xFU/–xFR models (U.S./Jpn versions):



Default jumper position [P24]–[PLC] and wiring example (used throughout this chapter)

–xFE models (Europe version):



Default jumper position [PLC]–[CM1] and wiring example

Forward Run/Stop and Reverse Run/Stop Commands

When you input the Run command via the dedicated terminal [FW], the inverter executes the Forward Run command (high) or Stop command (low). When you input the Run command via the programmable terminal [RV], the inverter executes the Reverse Run command (high) or Stop command (low).

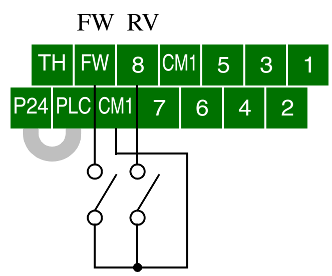
Opt. Code	Symbol	Function Name	State	Description
—	FW	Forward Run/Stop	ON	Inverter is in Run Mode, motor runs forward
			OFF	Inverter is in Stop Mode, motor stops
01	RV	Reverse Run/Stop	ON	Inverter is in Run Mode, motor runs reverse
			OFF	Inverter is in Stop Mode, motor stops

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008
Required settings:	A002 = 01

Notes:

- When the Forward Run and Reverse Run commands are active at the same time, the inverter enters the Stop Mode.
- When a terminal associated with either [FW] or [RV] function is configured for *normally closed*, the motor starts rotation when that terminal is disconnected or otherwise has no input voltage.

Example: (Default input configuration shown—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see examples above.)



See I/O specs on page 4–9.

NOTE: The parameter F004, Keypad Run Key Routing, determines whether the single Run key issues a Run FWD command or Run REV command. However, it has no effect on the [FW] and [RV] input terminal operation.

WARNING: If the power is turned ON and the Run command is already active, the motor starts rotation and is dangerous! Before turning power ON, confirm that the external Run command is not active.

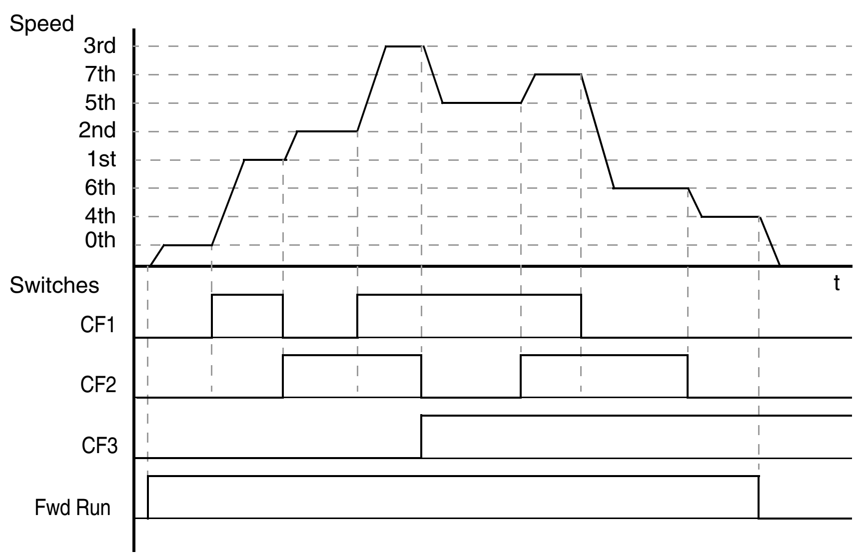
Multi-Speed Select

The inverter can store up to 16 different fixed target frequencies (speeds) in parameters A020 to A035. Binary inputs select the speed through four of the intelligent terminals configured as binary-encoded inputs CF1 to CF4 per the table. These can be any of the eight inputs, and in any order. You can use fewer inputs if you need eight or fewer speeds.

Multi-speed	Input Function				Multi-speed	Input Function			
	CF4	CF3	CF2	CF1		CF4	CF3	CF2	CF1
Speed 0	0	0	0	0	Speed 8	1	0	0	0
Speed 1	0	0	0	1	Speed 9	1	0	0	1
Speed 2	0	0	1	0	Speed 10	1	0	1	0
Speed 3	0	0	1	1	Speed 11	1	0	1	1
Speed 4	0	1	0	0	Speed 12	1	1	0	0
Speed 5	0	1	0	1	Speed 13	1	1	0	1
Speed 6	0	1	1	0	Speed 14	1	1	1	0
Speed 7	0	1	1	1	Speed 15	1	1	1	1

NOTE: When choosing a subset of speeds to use, always start at the top of the table, and with the least-significant bit: CF1, CF2, etc.

The example with eight speeds in the figure below shows how input switches configured for CF1 – CF3 functions can change the motor speed in real time.



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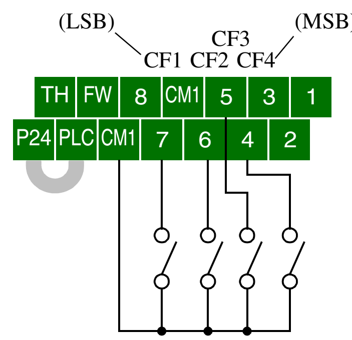
Opt. Code	Symbol	Function Name	Input State	Description
02	CF1	Binary speed select, Bit 0 (LSB)	ON	Bit 0, logical 1
			OFF	Bit 0, logical 0
03	CF2	Binary speed select, Bit 1	ON	Bit 1, logical 1
			OFF	Bit 1, logical 0
04	CF3	Binary speed binary select, Bit 2	ON	Bit 2, logical 1
			OFF	Bit 2, logical 0
05	CF4	Binary speed select, Bit 3 (MSB)	ON	Bit 3, logical 1
			OFF	Bit 3, logical 0

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008
Required settings:	F001, A020 to A035 A019=00

Notes:

- When programming the multi-speed settings, be sure to press the Store key each time and then set the next multi-speed setting. Note that when the Store key is not pressed, no data will be set.
- When a multi-speed setting more than 50Hz(60Hz) is to be set, it is necessary to program the maximum frequency A004 high enough to allow that speed.

Example: (Some CF inputs require input configuration; some are default inputs—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)



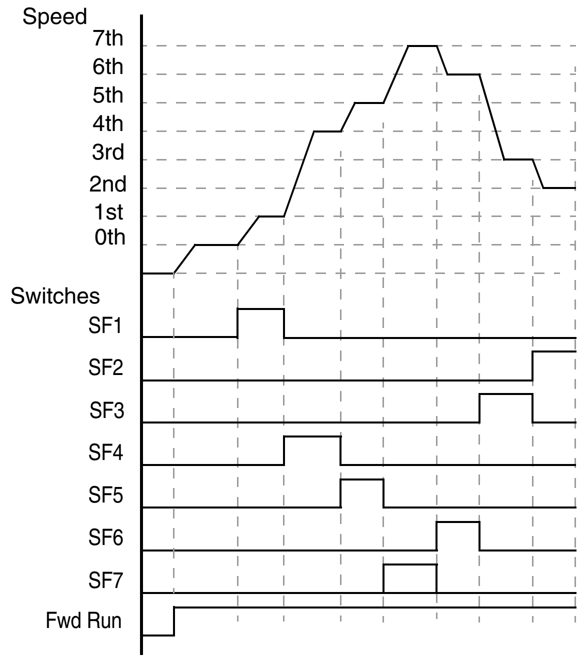
See I/O specs on page 4–9.

While using the multi-speed capability, you can monitor the output frequency with monitor function D001 during each segment of a multi-speed operation.
There are two ways to program the speeds into the registers A020 to A035:

1. Standard keypad programming:
   - **a.** Select each parameter A020 to A035.
   - **b.** Press the (FUNC) key to view the parameter value.
   - **c.** Use the (1) and (2) keys to edit the value.
   - **d.** Use the (STR) key to save the data to memory.
2. Programming using the CF switches:
   - **a.** Turn the Run command OFF (Stop Mode).
   - **b.** Turn inputs ON to select desired Multi-speed. Display the value of F001 on the digital operator.
   - **c.** Set the desired output frequency by pressing the (1) and (2) keys.
   - **d.** Press the (STR) key once to store the set frequency. When this occurs, F001 indicates the output frequency of the selected Multi-speed.
   - **e.** Press the (FUNC) key once to confirm that the indication is the same as the set frequency.
   - **f.** Repeat operations in 2. a) to 2. e) to set the frequency of other Multi-speeds. It can be set also by parameters A020 to A035 in the first procedure 1. a) to 1. d).

The Bit Operation method of speed control uses up to seven intelligent inputs to select from up to eight speeds. Since the all-switches-OFF combination selects the first speed, you only need N-1 switches to select N speeds. With Bit Operation speed control, only one input is normally active at a time. If multiple switches are ON, the lower numbered input takes precedence (determines the speed). The table and figure below show how the input combinations work.

Multi-speed	Input Function						
	SF7	SF6	SF5	SF4	SF3	SF2	SF1
Speed 0	0	0	0	0	0	0	0
Speed 1	—	—	—	—	—	—	1
Speed 2	—	—	—	—	—	1	0
Speed 3	—	—	—	—	1	0	0
Speed 4	—	—	—	1	0	0	0
Speed 5	—	—	1	0	0	0	0
Speed 6	—	1	0	0	0	0	0
Speed 7	1	0	0	0	0	0	0

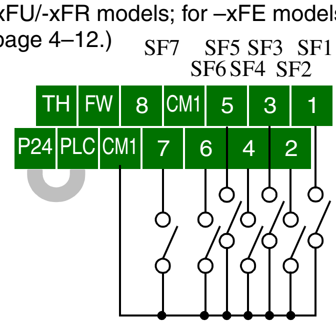


The following table lists the option codes for assigning [SF1 to SF7] to the intelligent inputs.

Opt. Code	Symbol	Function Name	Description
32	SF1	Bit-level speed select 1	Bit-level speed select, Bit 0
33	SF2	Bit-level speed select 2	Bit-level speed select, Bit 1
34	SF3	Bit-level speed select 3	Bit-level speed select, Bit 2
35	SF4	Bit-level speed select 4	Bit-level speed select, Bit 3
36	SF5	Bit-level speed select 5	Bit-level speed select, Bit 4
37	SF6	Bit-level speed select 6	Bit-level speed select, Bit 5
38	SF7	Bit-level speed select 7	Bit-level speed select, Bit 6
Valid for inputs:		C001, C002, C003, C004, C005, C006, C007, C008	Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:		F001, A020 to A035 A019=00	

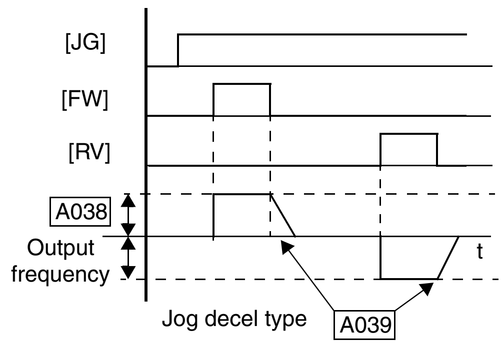
Notes:

- When all [SFx] inputs are OFF, the speed is set by default to the value in F001.
- When a multi-speed setting more than 50Hz(60Hz) is to be set, it is necessary to program the maximum frequency A004 high enough to allow that speed.



Jogging Command

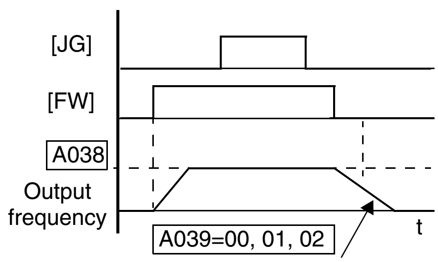
The Jog input [JG] is used to command the motor to rotate slowly in small increments for manual operation. The speed is limited to 10 Hz. The frequency for the jogging operation is set by parameter A038. Jogging does not use an acceleration ramp. Therefore setting the jogging frequency A038 too high will cause inverter tripping.



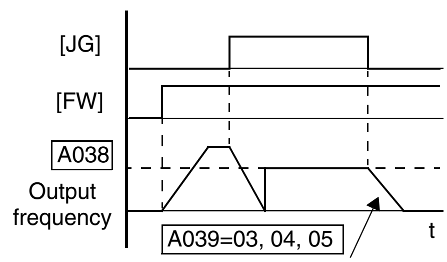
A jog command may arrive while the motor is running. You can program the inverter to either ignore or respond to a jog command in this case by using function A039. The type of deceleration used to end a motor jog is also selectable by programming function A039. Six jog mode options are defined below:

Jogging During Motor Operation		Jog Deceleration Method
Disabled, A039=	Enabled, A039=	
00	03	Free-run stop (coasting)
01	04	Deceleration (normal level) and stop
02	05	Use DC braking and stop

In the left example diagram below, the Jog command is ignored. In the right example diagram, a jog command interrupts a Run mode operation. However, if the Jog command turns ON before the [FW] or [RV] terminal turns ON, the inverter output turns OFF.



Decelerating stop (00) shown



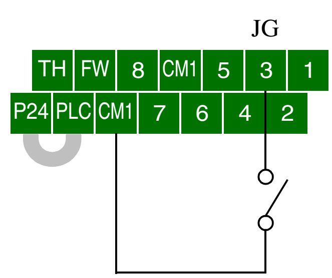
Free-run stop (05) shown

Opt. Code	Symbol	Function Name	Input State	Description
06	JG	Jogging	ON	Enters Jog Mode if enabled (see above)
			OFF	Jog is OFF

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Default input configuration shown—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	A002= 01, A038 > B082, A038 > 0, A039=00 to 05	

Notes:

- Jogging is not performed when the value of A038 jogging frequency is smaller than the start frequency B082 or the value is 0 Hz.
- Be sure to turn ON [FW] or [RV] *after* the [JG] input turns ON for a jog operation.
- When setting A039 to 02 or 05, you must also set the DC braking parameters.



See I/O specs on page 4–9.

External Signal for DC Braking

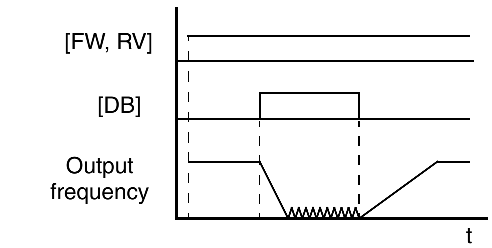
When the terminal [DB] is turned ON, the DC braking [DB] feature is enabled. Set the following parameters when the external DC braking terminal is to be used:

- A053 – DC braking delay time setting. The range 0.0 to 5.0 seconds.
- A054 – DC braking force setting. The range is 0 to 100%.

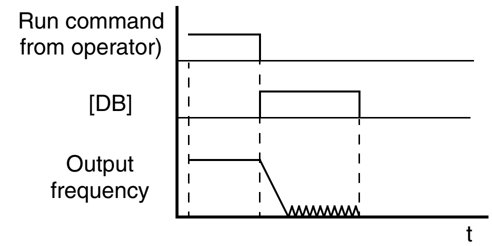
The scenarios to the right help show how DC braking works in various situations.

1. Scenario 1 – The [FW] Run or [RV] Run terminal is ON. When the [DB] terminal turns ON, DC braking is applied. When the [DB] terminal turns OFF again, the inverter output ramps to the previous frequency.
2. Scenario 2 – The Run command is applied from the operator keypad. When the [DB] terminal turns ON, DC braking is applied. When the [DB] terminal turns OFF again, the inverter output remains OFF.
3. Scenario 3 – The Run command is applied from the operator keypad. When the [DB] terminal turns ON, DC braking is applied after the delay time set by A053 expires. The motor is in a free-running (coasting) condition during this delay time. When the [DB] terminal turns OFF again, the inverter output remains OFF.

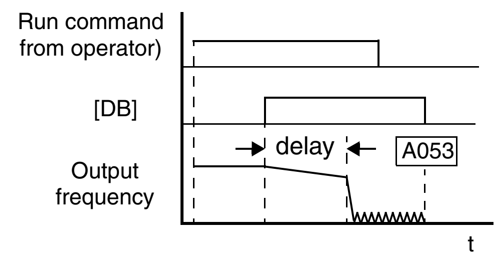
Scenario 1



Scenario 2



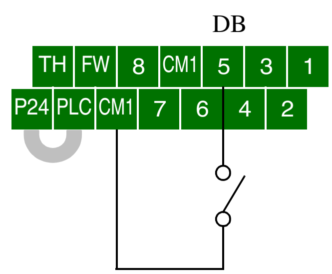
Scenario 3



Opt. Code	Symbol	Function Name	Input State	Description
07	DB	External Signal for DC Injection Braking	ON	applies DC injection braking during deceleration
			OFF	does not apply DC injection braking during deceleration
Valid for inputs:		C001, C002, C003, C004, C005, C006, C007, C008		Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:		A053, A054		

Notes:

- Do not use the [DB] input continuously or for a long time when the DC braking force setting A054 is high (depends on the motor application).
- Do not use the [DB] feature for continuous or high duty cycle as a holding brake. The [DB] input is designed to improve stopping performance. Use a mechanical brake for holding a stop position.



See I/O specs on page 4–9.

Set Second or Third Motors

If you assign the [SET] or [SET3] functions to an intelligent input terminal, you can select between two or three sets of motor parameters. You may assign one or both of these functions. These second and third parameters store alternate sets of motor characteristics. When terminal [SET] or [SET3] is turned ON, the inverter will use the second or third set of parameters accordingly, generating the frequency output to the motor. When changing the state of the [SET] or [SET3] input terminal, the change will not take effect until the inverter is stopped.

When you turn ON the [SET] or [SET3] input, the inverter operates per the second or third set of parameters, respectively. When the terminal is turned OFF, the output function returns to the original settings (first set of motor parameters). Refer to “Configuring the Inverter for Multiple Motors” on page 4–72 for details.

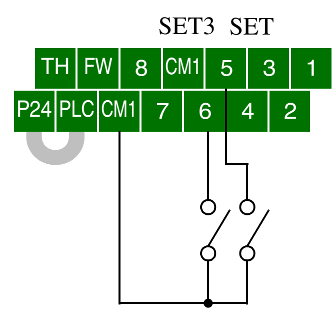
Opt. Code	Symbol	Function Name	Input State	Description
08	SET	Set 2nd Motor	ON	causes the inverter to use the 2nd set of motor parameters for generating the frequency output to motor
			OFF	causes the inverter to default to the 1st (main) set of motor parameters for generating the frequency output to motor
17	SET3	Set 3rd Motor	ON	causes the inverter to use the 3rd set of motor parameters for generating the frequency output to motor
			OFF	causes the inverter to default to the 1st (main) set of motor parameters for generating the frequency output to motor

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008
Required settings:	(none)

Notes:

- If the terminal state is changed while the inverter is running, the inverter continues using the current set of parameters until the inverter is stopped.
- If both SET and SET3 are ON at the same time, SET prevails and the 2nd motor parameters are in effect.

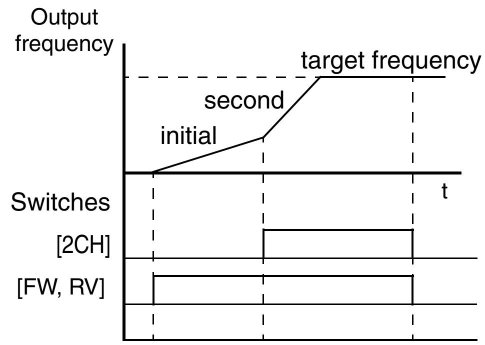
Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)



See I/O specs on page 4–9.

Two-stage Acceleration and Deceleration

When terminal [2CH] is turned ON, the inverter changes the rate of acceleration and deceleration from the initial settings (F002 and F003) to use the second set of acceleration/deceleration values. When the terminal is turned OFF, the inverter is returned to the original acceleration and deceleration time (F002 acceleration time 1, and F003 deceleration time 1). Use A092 (acceleration time 2) and A093 (deceleration time 2) to set the second stage acceleration and deceleration times.



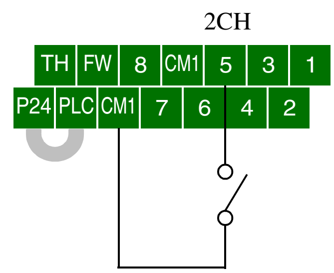
In the graph shown above, the [2CH] signal becomes active during acceleration. This causes the inverter to switch from using acceleration 1 (F002) to acceleration 2 (A092).

Opt. Code	Symbol	Function Name	Input State	Description
09	2CH	Two-stage Acceleration and Deceleration	ON	Frequency output uses 2nd-stage acceleration and deceleration values
			OFF	Frequency output uses the initial acceleration 1 and deceleration 1 values

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Default input configuration shown—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	A092, A093, A094=0	

Notes:

- Function A094 selects the method for second stage acceleration. It must be set = 00 to select the input terminal method in order for the [2CH] terminal assignment to operate.



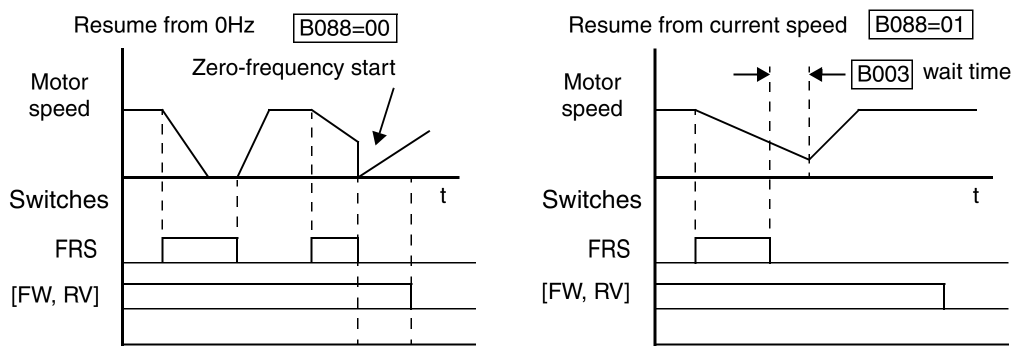
See I/O specs on page 4–9.

Free-run Stop

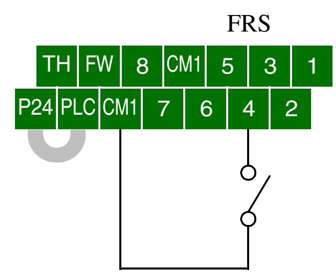
When the terminal [FRS] is turned ON, the inverter turns OFF the output and the motor enters the free-run state (coasting). If terminal [FRS] is turned OFF, the output resumes sending power to the motor if the Run command is still active. The free-run stop feature works with other parameters to provide flexibility in stopping and starting motor rotation.

In the figure below, parameter B088 selects whether the inverter resumes operation from 0 Hz (left graph) or the current motor rotation speed (right graph) when the [FRS] terminal turns OFF. The application determines the best setting.

Parameter B003 specifies a delay time before resuming operation from a free-run stop. To disable this feature, use a zero delay time.



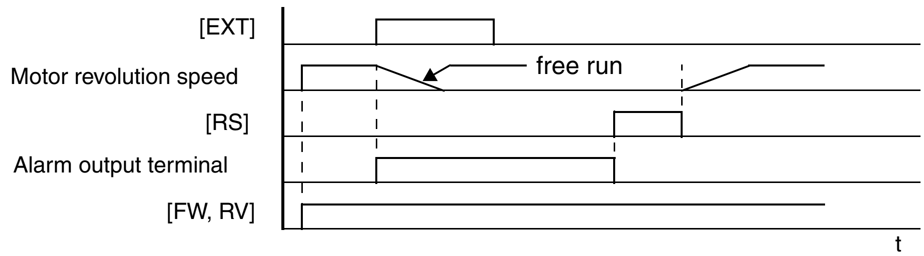
Opt. Code	Symbol	Function Name	Input State	Description
11	FRS	Free-run Stop	ON	Causes output to turn OFF, allowing motor to free run (coast) to stop
			OFF	Output operates normally, so controlled deceleration stops motor

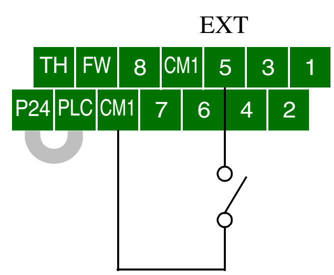
Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Default input configuration shown—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	B003, B088, C011 to C018	
Notes: • When you want the [FRS] terminal to be active low (normally closed logic), change the setting (C011 to C018) that corresponds to the input (C001 to C008) that is assigned the [FRS] function.		 See I/O specs on page 4–9.

External Trip

When the terminal [EXT] is turned ON, the inverter enters the trip state, indicates error code E12, and stops the output. This is a general purpose interrupt type feature, and the meaning of the error depends on what you connect to the [EXT] terminal. Even if [EXT] is turned OFF, the inverter remains in the trip state. You must reset the inverter or cycle power to clear the error, returning the inverter to the Stop Mode.

In the graph below, the [EXT] input turns ON during normal Run Mode operation. The inverter lets the motor free-run to a stop, and the alarm output turns ON immediately. When the operator initiates a Reset command, the alarm and error are cleared. When the Reset is turned OFF, the motor begins rotation since the Run command is already active.



<table>
<tr><th>Opt. Code</th><th>Symbol</th><th>Function Name</th><th>Input State</th><th>Description</th></tr>
<tr><td rowspan="2">12</td><td rowspan="2">EXT</td><td rowspan="2">External Trip</td><td>ON</td><td>When assigned input transitions OFF to ON, inverter latches trip event and displays E12</td></tr>
<tr><td>OFF</td><td>No trip event for ON to OFF, any recorded trip events remain in history until Reset</td></tr>
<tr><td colspan="2">Valid for inputs:</td><td colspan="2">C001, C002, C003, C004, C005, C006, C007, C008</td><td rowspan="3">Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)


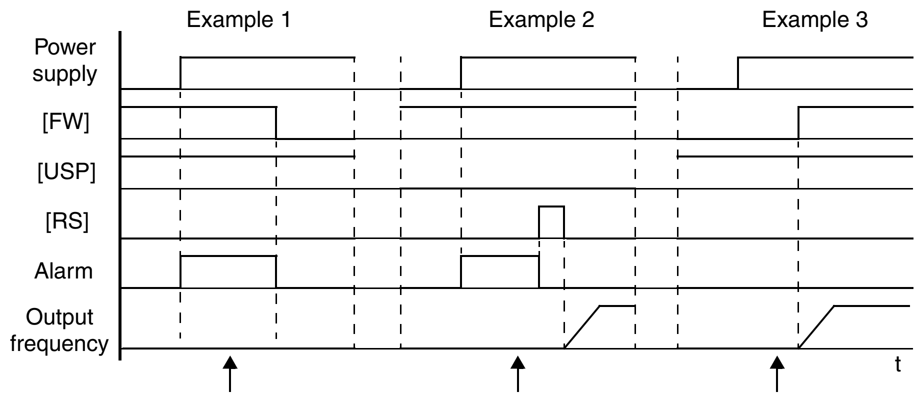
See I/O specs on page 4–9.</td></tr>
<tr><td colspan="2">Required settings:</td><td colspan="2">(none)</td></tr>
<tr><td colspan="4">Notes:
• If the USP (Unattended Start Protection) feature is in use, the inverter will not automatically restart after cancelling the EXT trip event. In that case, it must receive either another Run command (OFF-to-ON transition), a keypad Reset command, or an [RS] intelligent terminal input signal.</td></tr>
</table>

Unattended Start Protection

If the Run command is already present when power is turned ON, the inverter starts running immediately after powerup. The Unattended Start Protection (USP) function prevents that automatic startup, so that the inverter *will not* run without outside intervention. When USP is active, there are two ways to reset an alarm and resume running:

1. Turn the Run command OFF, or
2. Perform a reset operation by the terminal [RS] input or the keypad Stop/reset key

The three examples below show how the USP function works in the scenarios described at the bottom of the diagram. The error code E13 indicates the USP trip state and corresponds to the *Alarm* signal in the diagram.



When USP is ON after powerup, the alarm (E13) will clear when the Run command (FW or RV) turns OFF.

If the alarm is cleared during Run command, the inverter output restarts automatically.

If the Run command is already OFF at powerup, the inverter output starts normally.

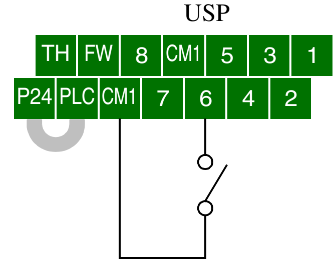
Opt. Code	Symbol	Function Name	Input State	Description
13	USP	Unattended Start Protection	ON	At powerup, the inverter will not resume a Run command
			OFF	At powerup, the inverter will resume a Run command that was active before power loss

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Dfault input configuration shown for -FU models; -FE and -F models require input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	(none)	

Notes:

- Note that when a USP error occurs and it is canceled by a reset from the [RS] terminal input or keypad, the inverter restarts immediately.
- Even when the trip state is canceled by turning the terminal [RS] ON and OFF after an under-voltage trip E09 occurs, the USP function will be performed.
- When the Run command is active immediately after the power is turned ON, a USP error will occur. When this function is used, wait for at least three (3) seconds after powerup before applying a Run command.

USP

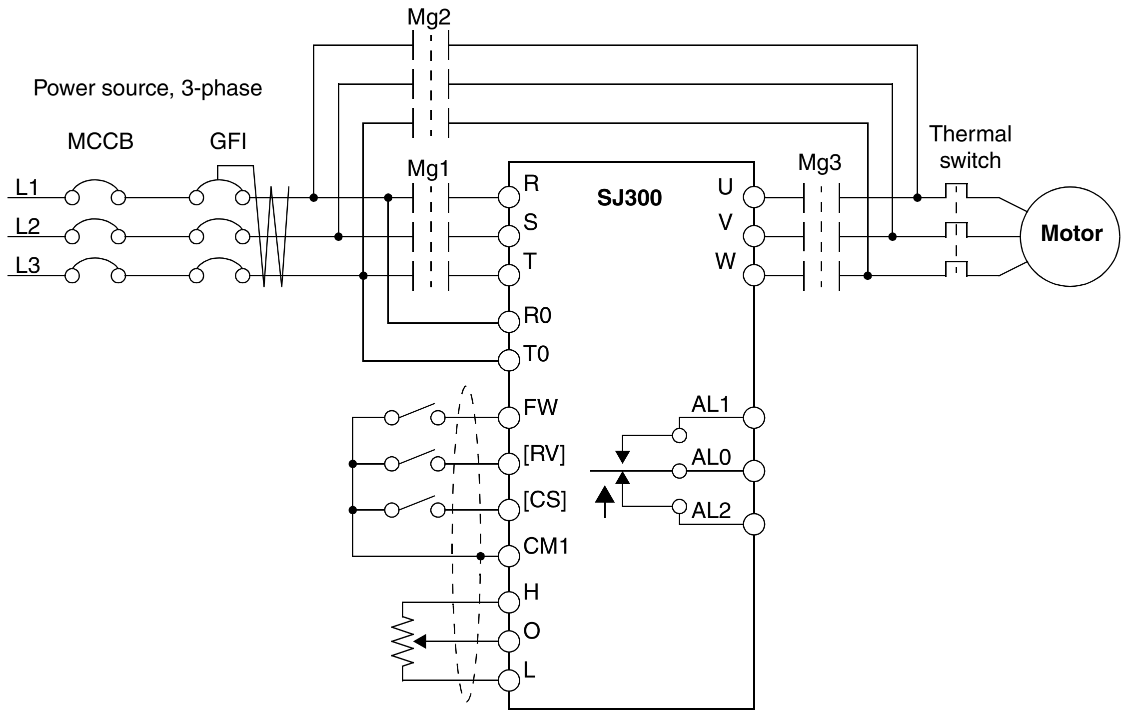


See I/O specs on page 4–9.

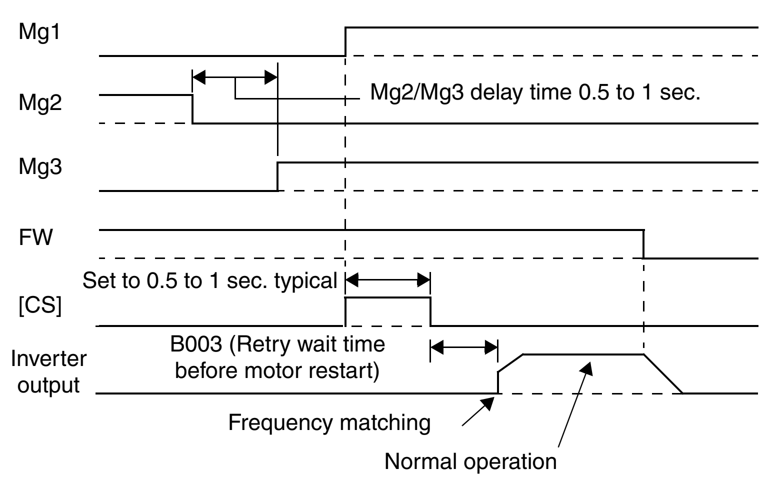
Commercial Power Source Switching

The commercial power source switching function is useful in systems with excessive starting torque requirements. This feature permits the motor to be started "across the line," sometimes called a *bypass* configuration. After the motor is running, the inverter takes over to control the speed. This feature can eliminate the need to oversize the inverter, reducing cost. However, additional hardware such as magnetic contactors will be required to realize this function. For example, a system may require 55KW to start, but only 15KW to run at constant speed. Therefore, a 15KW rated inverter would be sufficient when using the commercial power source switching.

The following block diagram shows an inverter system with *bypass* capability. When starting the motor directly across the line, relay contacts Mg2 are closed, and Mg1 and Mg3 are open. This is the bypass configuration, since the inverter is isolated from the power source and motor. Then Mg1 contacts close about 0.5 to 1 second after that, supplying power to the inverter.



Switching to inverter control occurs after the motor is running at full speed. First, Mg2 relay contacts open. Then about 0.5 to 1 seconds later, relay Mg3 contacts close, connecting the inverter to the motor. The following timing diagram shows the event sequence:

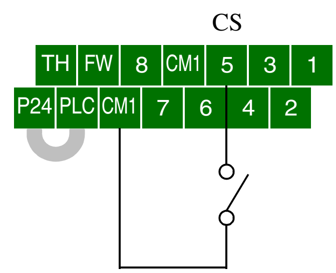


In the previous timing diagram, when the motor has been started across the line, Mg2 is switched OFF and Mg3 is switched ON. With the Forward command to the inverter already ON, the [CS] terminal is switched ON and relay Mg1 contacts close. The inverter will then read the motor RPM (frequency matching). When the [CS] terminal is switched OFF, the inverter applies the *Retry wait time before motor restar*t parameter (B003).

Once the delay time has elapsed the inverter will then start and match the frequency (if greater than the threshold set by B007). If the ground fault interrupter breaker (GFI) trips on a ground fault, the bypass circuit will not operate the motor. When an inverter backup is required, take the supply from the bypass circuit GFI. Use control relays for [FW], [RV], and [CS].

The commercial power source switching function requires you to assign [CS] to an intelligent input terminal, using option code 14.

Opt. Code	Symbol	Function Name	Input State	Description
14	CS	Commercial Power Change	ON	OFF-to-ON transition signals the inverter that the motor is already running at powerup (via bypass), thus suppressing the inverter's motor output in Run Mode
			OFF	ON-to-OFF transition signals the inverter to apply a time delay (B003), frequency match its output to existing motor speed, and resume normal Run Mode operation

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	B003, B007	
Notes: • If an over-current trip occurs during frequency matching, extend the retry wait time B003.		

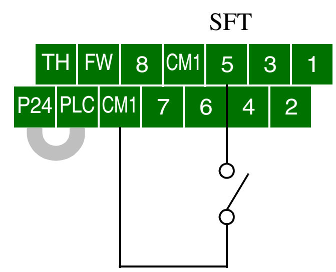
See I/O specs on page 4–9.

Software Lock

When the terminal [SFT] is turned ON, the data of all the parameters and functions (except the output frequency, depending on the setting of B031) is locked (prohibited from editing). When the data is locked, the keypad keys cannot edit inverter parameters. To edit parameters again, turn OFF the [SFT] terminal input.

Use parameter B031 to select whether the output frequency is excluded from the lock state or is locked as well.

Opt. Code	Symbol	Function Name	Input State	Description
15	SFT	Software Lock	ON	The keypad and remote programming devices are prevented from changing parameters
			OFF	The parameters may be edited and stored

<table>
<tr><td>Valid for inputs:</td><td>C001, C002, C003, C004, C005, C006, C007, C008</td><td rowspan="3">Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)

See I/O specs on page 4–9.</td></tr>
<tr><td>Required settings:</td><td>B031 (excluded from lock)</td></tr>
<tr><td colspan="2">Notes:
• When the [SFT] terminal is turned ON, only the output frequency can be changed.
• Software lock can include the output frequency by setting B031.
• Software lock by the operator is also possible without the [SFT] terminal being used (B031).</td></tr>
</table>

Analog Input Current/Voltage Select

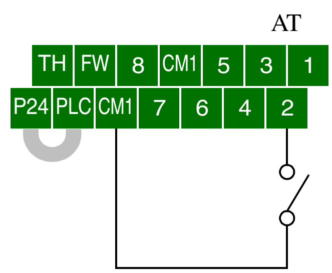
The [AT] terminal operates in conjunction with parameter setting A005 to determine the analog input terminals that are enabled for current or voltage input. Setting A006 determines whether the signal will be bipolar, allowing for a reverse direction range. Note that current input signal cannot be bipolar and cannot reverse direction (must use [FW] and [RV] command with current input operation). The following table shows the basic operation of the [AT] intelligent input. Please refer to “Analog Input Operation” on page 4–59 for more information on bipolar input configuration, and the operating characteristics of analog inputs.

Opt. Code	Symbol	Function Name	Input State	Description
16	AT	Analog Input Voltage/current Select	ON	• With A005 = 00, [AT] will enable terminals [OI]–[L] for current input, 4 to 20mA • With A005=01, [AT] will enable terminals [O2]–[L] for voltage input
			OFF	Terminals [O]–[L] are enabled for voltage input (A005 may be equal to 00 or 01) in this case

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Default input configuration shown—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	A001 = 01 A005 = 00 / 01 A006 = 00 / 01 / 02	

Notes:

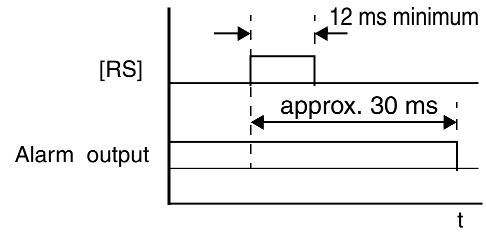
- Be sure to set the frequency source setting A001=01 to select the analog input terminals.



See I/O specs on page 4–9.

Reset Inverter

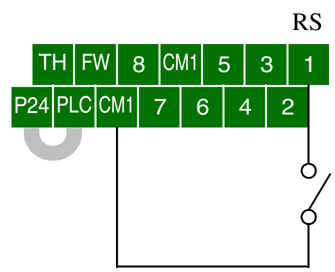
The [RS] terminal causes the inverter to execute the reset operation. If the inverter is in Trip Mode, the reset cancels the Trip state. When the signal [RS] is turned ON and OFF, the inverter executes the reset operation. The minimum pulse width for [RS] must be 12 ms or greater. The alarm output will be cleared within 30 ms after the onset of the Reset command.



WARNING: After the Reset command is given and the alarm reset occurs, the motor will restart suddenly if the Run command is already active. Be sure to set the alarm reset after verifying that the Run command is OFF to prevent injury to personnel.

Opt. Code	Symbol	Function Name	Input State	Description
18	RS	Reset Inverter	ON	The motor output is turned OFF, the Trip Mode is cleared (if it exists), and powerup reset is applied
			OFF	Normal power-on operation

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Default input configuration shown—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	B003, B007, C102, C103	



See I/O specs on page 4–9.

Notes:

- When the control terminal [RS] input is already ON at powerup for more than 4 seconds, the remote operator display is “R-ERROR COMM<2>” (the display of the digital operator is – – – –). However, the inverter has no error. To clear the digital operator error, turn OFF the terminal [RS] input and press one of the operator keys.
- The active edge (leading or trailing) of the [RS] signal is determined by the setting of C102.
- A terminal configured with the [RS] function can only be configured as a normally open contact. The terminal cannot be used in the normally closed contact state.
- When input power is turned ON, the inverter performs the same reset operation as it does when a pulse on the [RS] terminal occurs.

Thermistor Thermal Protection

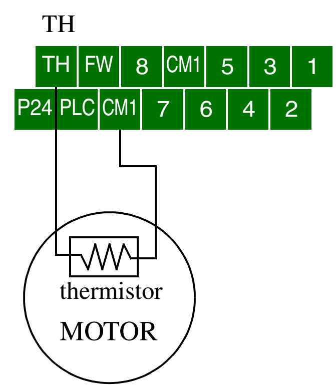
Motors that are equipped with a thermistor can be protected from overheating. Input terminal [TH] is dedicated to sense a thermistor resistance. The input can be set up (via B098 and B099) to accept a wide variety of NTC or PTC type thermistors. Use this function to protect the motor from overheating.

Opt. Code	Symbol	Function Name	Input State	Description
—	TH	Thermistor Thermal Protection	Sensor	When a thermistor is connected between to terminals [TH] and [CM1], the inverter checks for over-temperature and will cause a trip (E35) and turn OFF the output to the motor
			Open	An open circuit in the thermistor causes a trip, and the inverter turns OFF the output

Valid for inputs:	[TH] only
Required settings:	B098 and B099

Notes:
- Be sure the thermistor is connected to terminals [TH] and [CM1]. If the resistance is above or below (depending on whether NTC or PTC) the threshold the inverter will trip. When the motor cools down enough, the thermistor resistance will change enough to permit you to clear the error. Press the STOP/Reset key to clear the error.

Example:



See I/O specs on page 4–9.

Three-wire Interface Operation

The 3-wire interface is an industry standard motor control interface. This function uses two inputs for momentary contact start/stop control, and a third for selecting forward or reverse direction. To implement the 3-wire interface, assign 20 [STA] (Start), 21 [STP] (Stop), and 22 [F/R] (Forward/Reverse) to three of the intelligent input terminals. Use momentary contact for Start and Stop. Use a selector switch, such as SPST for the Forward/Reverse input. Be sure to set the operation command selection A002=01 for input terminal control of motor.

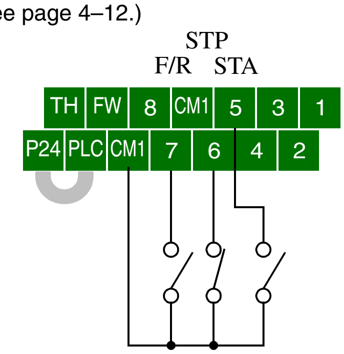
If you have a motor control interface that needs logic-level control (rather than momentary pulse control), use the [FW] and [RV] inputs instead.

Opt. Code	Symbol	Function Name	Input State	Description
20	STA	Start Motor	ON	Start motor rotation on momentary contact (uses acceleration profile)
			OFF	No change to motor operation
21	STP	Stop Motor	ON	No change to motor operation
			OFF	Stop motor rotation on momentary contact (uses deceleration profile)
22	F/R	Forward/Reverse	ON	Select *reverse* direction of rotation
			OFF	Select *forward* direction of rotation

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008
Required settings:	A002=01

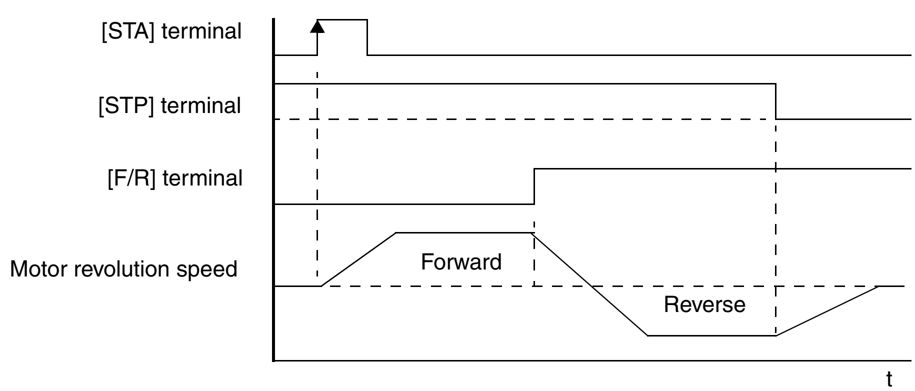
Notes:
- The STP logic is inverted. Normally the switch will be closed, so you open the switch to stop. In this way, a broken wire causes the motor to stop automatically (safe design).
- When you configure the inverter for 3-wire interface control, the dedicated [FW] terminal is automatically disabled. The [RV] intelligent terminal assignment is also disabled.

Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)



See I/O specs on page 4–9.

The diagram below shows the use of 3-wire control. STA (Start Motor) is an edge-sensitive input; an OFF-to-ON transition gives the Start command. The control of direction is level-sensitive, and the direction may be changed at any time. STP (Stop Motor) is also a level-sensitive input.



PID ON/OFF and PID Clear

The PID loop function is useful for controlling motor speed to achieve constant flow, pressure, temperature, etc. in many process applications. The PID Disable function temporarily suspends PID loop execution via an intelligent input terminal. It overrides the parameter A071 (PID Enable) to stop PID execution and return to normal motor frequency output characteristics. the use of PID Disable on an intelligent input terminal is optional. Of course, any use of the PID loop control requires setting PID Enable function A071=01.

The PID Clear function forces the PID loop integrator sum = 0. So, when you turn ON an intelligent input configured as [PIDC], the integrator sum is reset to zero. This is useful when switching from manual control to PID loop control and the motor is stopped.

CAUTION: Be careful not to turn PID Clear ON and reset the integrator sum when the inverter is in Run Mode (output to motor is ON). Otherwise, this could cause the motor to decelerate rapidly, resulting in a trip.

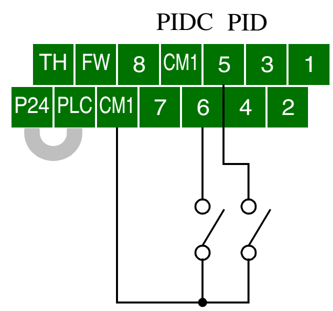
Opt. Code	Symbol	Function Name	Input State	Description
23	PID	PID Disable	ON	Disables PID loop execution
			OFF	Allows PID loop execution if A71=01
24	PIDC	PID Clear	ON	Force the value of the integrator to zero
			OFF	No change to PID loop execution

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008
Required settings:	A071

Notes:

- The use of [PID] and [PIDC] terminals are optional. Use A071=01 if you want PID loop control enabled all the time.
- Do not enable/disable PID control while the motor is running (inverter is in Run Mode).
- Do not turn ON the [PIDC] input while the motor is running (inverter is in Run Mode).

Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)



See I/O specs on page 4–9.

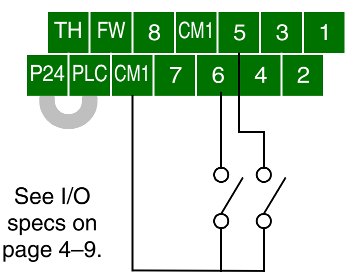
Internal Speed Loop Gain Settings

When sensorless vector control, 0Hz sensorless vector control, or vector control with sensor is selected for the control method, the Control Gain Switching function selects between two sets of gains in the internal speed loop. These gains are used in proportional and integral compensation. Use option code 26 to assign the [CAS] function to an intelligent input terminal. Use option code 43 to select between P and PI control.

Opt. Code	Symbol	Function Name	Input State	Description
26	CAS	Control Gain Switching	ON	Gains in parameters H070, H071, and H072 are selected
			OFF	Gains in parameters H050, H051, H052; or, H250, H251, H252 (2nd motor) are selected
43	PPI	P / PI Control Switching	ON	Selects Proportional control (P)
			OFF	Selects Proportional-Integral control (PI)

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	A044 / A244 / A344 = 03 (SLV), or 04 (0 Hz domain), or 05 (V2)	
Notes: • When Control Gain Switching is not selected for an intelligent input terminal, the default gains in effect correspond to the OFF state of [CAS].		

PPI CAS

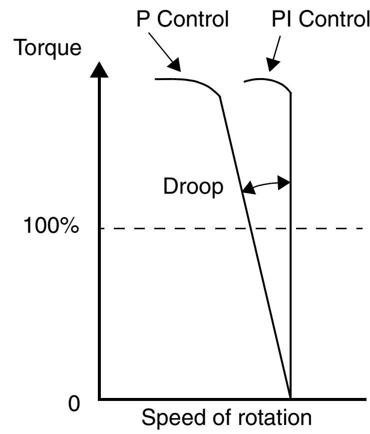


See I/O specs on page 4–9.

The table below lists the functions and parameter settings related to internal speed loop gains.

Function Code	Parameter	Setting Range	Description
A044 / A244 / A344	Control method selection	03	SLV (does not use A344)
		04	0-Hz Domain SLV (does not use A344)
		05	V2 (does not use A244 or A344)
C001 - C008	Intelligent input selection	43	PPI : P/I switching
H005 / H205	Speed response	0.001 to 65.53	No dimension
H050 / H250	PI proportional gain	0.0 to 999.9/1000	% gain
H051 / H251	PI integral gain	0.0 to 999.9/1000	% gain
H052 / H252	P proportional gain	0.01 to 10.00	No dimension
H070	PI proportional gain for switching	0.0 to 999.9/1000	% gain
H071	PI integral gain for switching	0.0 to 999.9/1000	% gain
H072	P proportional gain for switching	0.0 to 10.0	No dimension

The speed control mode is normally proportional-integral compensation (PI), which attempts to keep the deviation between the actual speed and speed command equal to zero. You can also select proportional (P) control function, which can be used for *droop* control (i.e. several inverters driving one load). *Droop* is the speed difference resulting from P control versus PI control at 100% output torque as shown in the graph. Set the P/PI switching function (option 43) to one of the intelligent input terminals [1] to [8]. When the P/PI input terminal is ON, the control mode becomes proportional control (P). When the P/PI input terminal is OFF, the control mode becomes proportional-integral control.



The proportional gain Kpp value determines the droop. Set the desired value using parameter H052. The relationship between the Kpp value and the droop is shown below:

$$\text{Droop} = \frac{10}{(\text{Kpp Set Value})}(\%)$$

The relationship between the droop and the rated rotation speed is shown below:

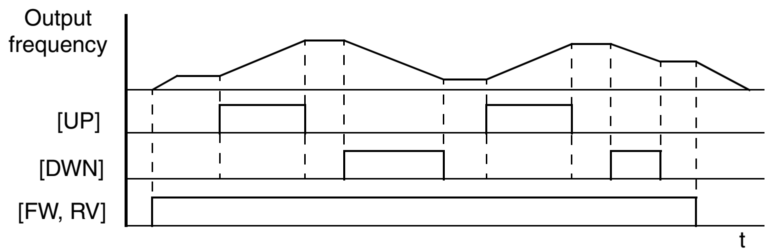
$$\text{Droop} = \frac{\text{Speed error at rated torque}}{\text{Synchronous speed base frequency}}$$

Remote Control Up and Down Functions

The [UP] [DWN] terminal functions can adjust the output frequency for remote control while the motor is running. The acceleration time and deceleration time used with this function is the same as for normal operation ACC1 and DEC1 (2ACC1,2DEC1). The input terminals operate as follows:

- Acceleration - When the [UP] contact is turned ON, the output frequency accelerates from the current value. When it is turned OFF, the output frequency maintains its current value.
- Deceleration - When the [DWN] contact is turned ON, the output frequency decelerates from the current value. When it is turned OFF, the output frequency maintains its current value.

In the graph below, the [UP] and [DWN] terminals activate while the Run command remains ON. The output frequency responds to the [UP] and [DWN] commands.



It is possible for the inverter to retain the frequency set from the [UP] and [DWN] terminals through a power loss. Parameter C101 enables/disables the memory. If disabled, the inverter retains the last frequency before an UP/DWN adjustment. Use the [UDC] terminal to clear the memory and return to the original set output frequency.

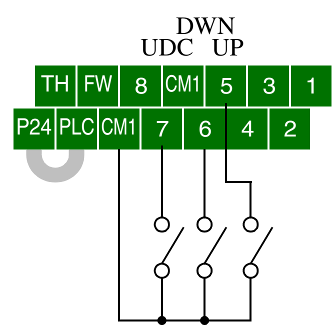
Opt. Code	Symbol	Function Name	Input State	Description
27	UP	Remote Control UP Function	ON	Accelerates (increases output frequency) motor from current frequency
			OFF	Output to motor operates normally
28	DWN	Remote Control DOWN Function	ON	Decelerates (decreases output frequency) motor from current frequency
			OFF	Output to motor operates normally
29	UDC	Remote Control Data Clear	ON	Clears the Up/down frequency memory
			OFF	No effect on Up/down memory

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008
Required settings:	A001 = 02 C101 = 01 (enables memory)

Notes:

- This feature is available only when the frequency command source is programmed for operator control. Confirm A001 is set to 02.
- This function is not available when [JG] is in use.
- The range of output frequency is 0 Hz to the value in A004 (maximum frequency setting).
- The Remote Control Up/Down function varies the inverter speed by directly writing to the F001 output frequency setting.

Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)



See I/O specs on page 4–9.

Force Operation from Digital Operator

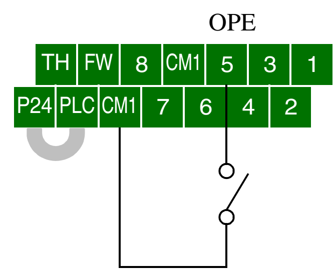
This function permits a digital operator interface to override the Run command source setting (A002) when it is configured for a source other than the operator interface. When the [OPE] terminal is ON and the operator interface gives a Run command, the inverter uses the standard output frequency settings to operate the motor.

Opt. Code	Symbol	Function Name	Input State	Description
31	OPE	Force Operation from Digital Operator	ON	Forces the operator interface Run command to over-ride commands from input terminals (such as [FW], [RV]).
			OFF	Run command operates normally, as configured by A002

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	A001 A002 (set not equal to 02)	

Notes:

- When changing the [OPE] state during Run Mode (inverter is driving the motor), the inverter will stop the motor before the new [OPE] state takes effect.
- If the [OPE] input turns ON and the digital operator gives a Run command while the inverter is already running, the inverter stops the motor. Then the digital operator can control the motor.



See I/O specs on page 4–9.

Overload Restriction

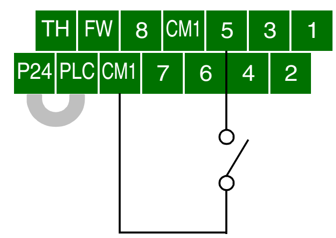
The inverter constantly monitors the motor current during acceleration, deceleration, and constant speed. If the inverter reaches the overload restriction level, it adjusts the output frequency automatically to limit the amount of overload. This function prevents an over-current trip by inertia during rapid acceleration or large changes in load at constant speed. It also attempts to prevent an over-voltage trip on deceleration due to regeneration. It accomplishes this by temporarily suspending deceleration and/or increasing the frequency in order to dissipate regenerative energy. Once the DC bus voltage falls sufficiently, deceleration will resume.

OLR Parameter Selection – Two sets of overload restriction parameter settings and values are available as outlined in the table below. Use the B021—B026 group of settings to configure the two set of parameters as needed. By assigning the Overload Restriction function [OLR] to an intelligent terminal, you can select the set of restriction parameters that is in effect.

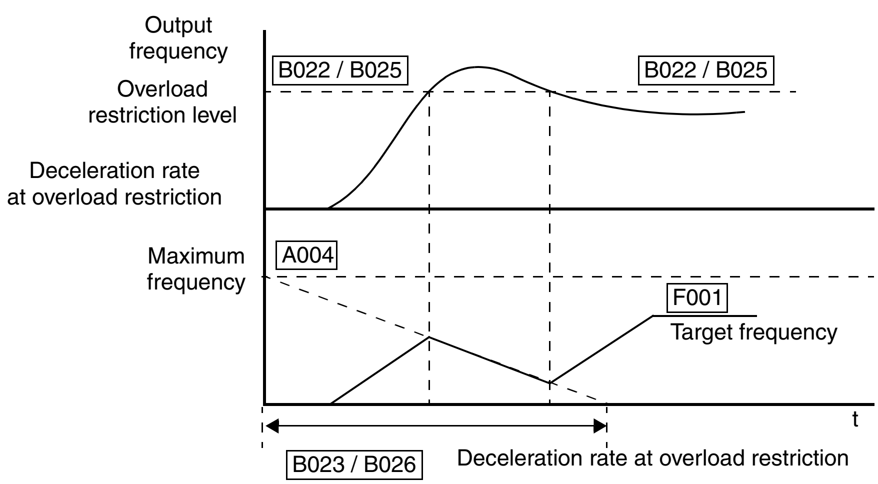
Function	Function Code		Data or Range	Description
	Set 1	Set 2		
Overload Restriction Operation Mode	B021	B024	00	Disable
			01	Enabled during accel and constant speed
			02	Enabled during constant speed
			03	Enabled during accel, constant speed, and decel
Overload Restriction Setting	B022	B025	Rated current * 0.5 to rated current * 2	Current value at which the restriction begins
Deceleration Rate at Overload Restriction	B023	B026	0.1 to 30 seconds	Deceleration time when overload restriction operates

.

Opt. Code	Symbol	Function Name	Input State	Description
39	OLR	Overload Restriction Selection	ON	Selects Overload Restriction Set 2, B024, B025, B026 settings in effect
			OFF	Selects Overload Restriction Set 1, B021, B022, B023 settings in effect

Opt. Code	Symbol	Function Name	Input State	Description
Valid for inputs:		C001, C002, C003, C004, C005, C006, C007, C008		Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.) OLR  See I/O specs on page 4–9.
Required settings:		B021, B022, B023 (Mode 1), B024, B025, B026 (Mode 2)		
Notes: • If the overload restriction constant (B023 or B026) is set too short, an over-voltage trip during deceleration will occur due to regenerative energy from the motor. • When an overload restriction occurs during acceleration, the motor will take longer to reach the target frequency, or may not reach it. The inverter will make the following adjustments: a) Increase the acceleration time b) Raise torque boost c) Raise overload restriction level				

The figure below shows the operation during an overload restriction event. The overload restriction level is set by B022 and B025. The overload restriction constant is the time to decelerate to 0Hz from maximum frequency. When this function operates, the acceleration time will be longer than the normal acceleration time.



NOTE: The Overload Advance Notice function for intelligent outputs is related to Overload Restriction operation, discussed in “Overload Advance Notice Signal” on page 4–46.

Torque Limit

The Torque Limit function limits the motor output torque for sensorless vector control, sensorless vector control 0Hz domain, or vector control with feedback.

In the torque limit function, the following operational modes are available (selected by B040):

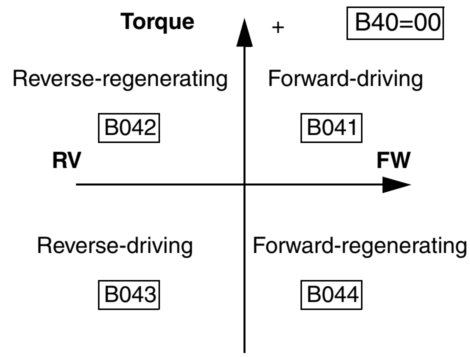
1. Four-quadrant individual setting mode – This mode sets torque limit in 4 zones, forward driving and regenerating, reverse driving and regenerating. Limits for each quadrant are set with B041 – B044 individually.
2. Terminal selection mode – By use of torque limit select intelligent input terminals 1 and 2, this mode changes and uses torque limits 1 – 4 set in B041 – B044. Selected torque limit range is valid in all four quadrants.
3. Analog input mode – This mode sets torque limit value by the voltage applied to terminal [O2] (referenced to [L] for ground. An input of 0 – 10V corresponds to the torque limit value of 0 to 200%. The selected torque limit value is valid in all four quadrants (whether forward or reverse move, driving or regenerating).
4. Expansion Cards 1 and 2 – This function is valid when using the expansion card (SJ-DG). Please refer to the SJ-DG instruction manual.

When the torque limit enable function [TL] is assigned to an intelligent input terminal, torque limiting occurs only when [TL] is ON. When the [TL] input is OFF, the inverter always uses the default torque control limit of 200% maximum. That torque limit value corresponds to 200% of the maximum inverter output current. Therefore, the output torque also depends on the particular motor in use. When the over-torque output [OTQ] is assigned in the intelligent output selection, it turns ON when the inverter is performing torque limiting.

Code	Function	Data or Range	Description
A044 / A244	Control method selection	00 01 02 03 04 05	V/f Constant torque V/f Variable torque V/f Free-setting torque *1 Sensorless vector *1 Sensorless vector, 0 Hz domain *1 Vector control with sensor *2
B040	Torque limit selection	00 01 02 03 04	4-quadrant individual setting Terminal selection Analog [O2] input Expansion card 1 Expansion card 2
B041	Torque limit 1	0 to 200%	Forward-driving in 4-quadrant mode
B042	Torque limit 2	0 to 200%	Reverse-regenerating in 4-quadrant mode
B043	Torque limit 3	0 to 200%	Reverse-driving in 4-quadrant mode
B044	Torque limit 4	0 to 200%	Forward-regenerating in 4-quadrant mode
C001 to C008	Intelligent input terminal [1] to [8] function	40 41 42	Torque limit enable Torque limit selection, bit 1 (LSB) Torque limit selection, bit 2 (MSB)
C021 to C025	Intelligent output terminal [11] to [15] function	10	In torque limit

Note 1: Unavailable for A344
Note 2: Unavailable for A244 and A344

The 4-quadrant operation mode for torque limiting (B040=00) is illustrated in the figure to the right. The instantaneous torque depends on inverter activity (acceleration, constant speed, or deceleration), as well as the load. These factors determine the operating quadrant at any particular time. The parameters in B041, B042, B043 and B044 determine the amount of torque limiting that the inverter applies.



The terminal selection mode (B040=01) uses two intelligent inputs [TRQ1] and [TRQ2] for the binary-encoded selection of one of the four torque limit parameters B041, B042, B043 and B044.

Opt. Code	Symbol	Function Name	Input State	Description
40	TL	Torque limit enable	ON	Enables torque limiting
			OFF	Disables torque limiting
41	TRQ1	Torque limit select 1	0 / 1	Torque limit select, Bit 1 (LSB)
42	TRQ2	Torque limit select 2	0 / 1	Torque limit select, Bit 2 (MSB)

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008
Required settings:	B040, B041, B042, B043, B044

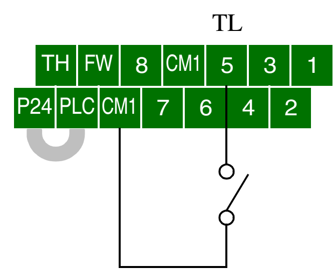
Notes:

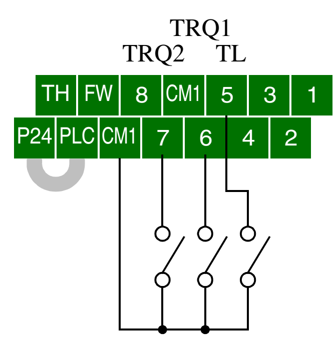
- Both the 4-quadrant mode and terminal switching mode of torque limiting use input [TL] for enable/disable.
- Inputs TRQ1 and TRQ2 apply only to terminal switching mode.

Intelligent Inputs		Torque limit parameter
TRQ2	**TRQ1**	
OFF	OFF	B041
OFF	ON	B042
ON	OFF	B043
ON	ON	B044

- When using the torque limit function at low speed, also use the overload restriction feature.

Examples: (Require input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)



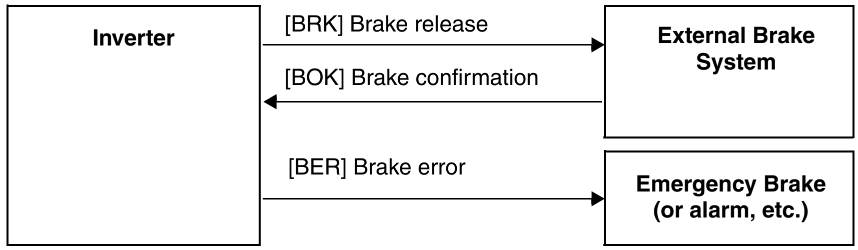


See I/O specs on page 4–9.

Operations and Monitoring

External Brake Control Function

The External Brake Control function enables the inverter to control external electromechanical brake systems with a particular safety characteristic. For example, elevator control systems maintain the brake on the load until the drive motor has reached a *releasing* frequency (point at which the external mechanical brake is released). This ensures that the load does not have an opportunity to begin coasting before the inverter begins driving the motor. The External Brake Control function can be enabled by setting parameter B120=01. The diagram below shows the signals that are important to this function.



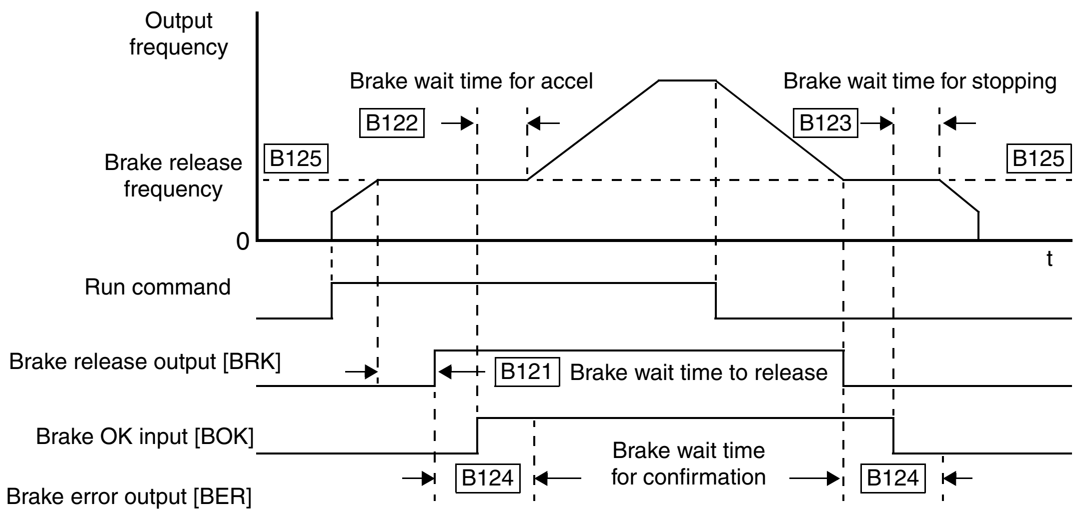
The steps below describe the timing diagram of events on the following page.

1. When the Run command turns ON, the inverter begins to operate and accelerate to releasing frequency (B125).
2. After the output frequency arrives at the set releasing frequency (B125), the inverter waits for the brake release confirmation, set by B121. The inverter outputs the braking release signal [BRK]. However, if the output current of the inverter is less than the releasing current set by B126, the inverter does not turn ON the brake release output [BRK]. The lack of the proper current level indicates a fault (such as open wire to motor). In this case, the inverter trips and outputs the braking error signal [BER]. This signal is useful to engage an emergency brake to ensure the load does not move, if the primary braking system has failed.
3. While the brake release output [BRK] is ON, the inverter drives the motor but does not accelerate immediately. The inverter waits for confirmation from the external brake. When the external brake system properly releases, it signals the inverter by using the Brake OK input terminal [BOK].
4. When the brake operates properly and signals with the [BOK] input, the inverter waits for the required time for acceleration (B122), and then begins to accelerate to the set target frequency.
5. When the Run command turns OFF, the procedure outlined above happens in reverse. The idea is to engage the brake before the motor comes completely to a stop. The inverter decelerates to the releasing frequency (B125) and turns the brake release output [BRK] OFF to engage the brake.
6. The inverter does not decelerate further during just the waiting time for brake confirmation (B121). If the brake confirmation signal does not turn OFF within the waiting time for brake confirmation, the inverter causes a trip alarm and outputs the brake error signal [BER] (useful for engaging an emergency brake system).
7. Normally, the brake confirmation signal [BOK] turns OFF, and the inverter waits the required waiting time. Then the inverter begins to decelerate again and brings motor and load to a complete stop (see timing diagram on next page).

Code	Function	Data or Range	Description
B120	Brake control enable	00=Disable 01=Enable	Enables external brake control function within the inverter
B121	Brake waiting time for release	0.00 to 5.00 sec.	Sets the time delay after arrival at release frequency (B125) before the inverter outputs brake release signal [BRK]
B122	Brake wait time for acceleration	0.00 to 5.00 sec.	Sets time delay after brake confirmation signal [BOK] is received until the inverter begins to accelerate to the set frequency

Code	Function	Data or Range	Description
B123	Brake wait time for stopping	0.00 to 5.00 sec.	Sets the time delay after brake confirmation signal [BOK] turns OFF (after [BRK] turns OFF) until decelerating the inverter to 0 Hz
B124	Brake wait time for confirmation	0.00 to 5.00 sec.	Sets the wait time for [BOK] signal after turn ON/ OFF of [BRK] signal. If [BOK] is not received during the specified time, the inverter will trip with an external brake error [BER].
B125	Break release frequency setting	0.00 to 99.99 Hz / 100.0 to 400.0 Hz	Sets the frequency at which the inverter outputs the brake release signal [BRK] after delay set by B121
B126	Brake release current setting	0% to 200% of rated current	Sets the minimum inverter current level above which the brake release signal [BRK] will be permitted

The diagram below shows the event sequence described in the steps on the previous page.



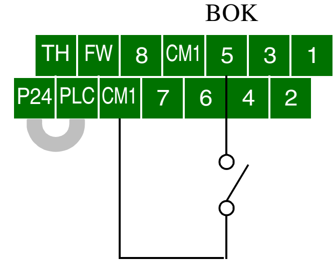
The following table pertains to the brake confirmation input.

Opt. Code	Symbol	Function Name	Input State	Description
44	BOK	Brake confirmation	ON	Indicates external brake is not engaged
			OFF	Indicates external brake is engaged

Valid for inputs:	C001, C002, C003, C004, C005, C006, C007, C008	Example: (Requires input configuration—see page 3–47. Jumper position shown is for –xFU/-xFR models; for –xFE models, see page 4–12.)
Required settings:	B120=01 B121 to B126 set	

Notes:

- The signal [BOK] turns ON to indicate that an external brake system has released. If external brake control is enabled (B120=01), then the [BOK] signal must work properly to avoid an inverter trip event.



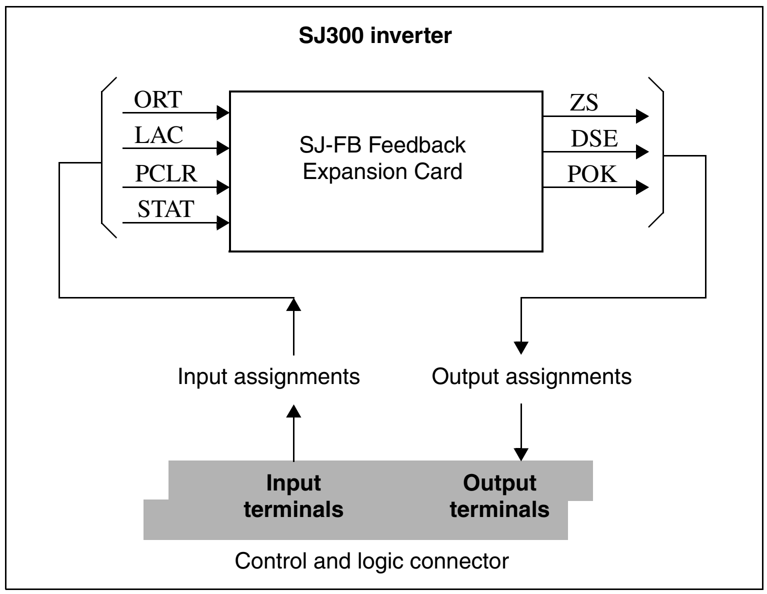
See I/O specs on page 4–9.

Expansion Card Input Signals

Other inputs listed below require the expansion card SJ-FB Encoder Feedback. Please see the SJ-FB manual for more information.

Opt. Code	Symbol	Function Name	Description
45	ORT	Orientation	Orientation (home search sequence)
46	LAC	LAD Cancel	Cancels the linear acceleration/deceleration position control in the feedback card
47	PCLR	Position deviation clear	Forces the position error to zero
48	STAT	Pulse train input enable	Starts the pulse train control of motor frequency

The diagram below shows how the Input/Output connections for the SJ–FB feedback board. The inverter's internal connections and parameter configuration make these signals available on intelligent input and output terminals.

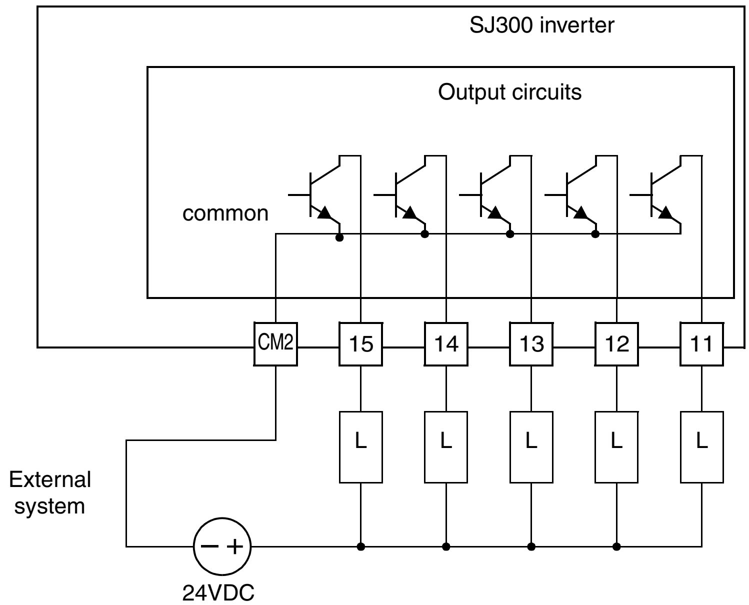


The information on outputs related to the SJ-FB expansion card is in "Expansion Card Output Signals" on page 4–58.

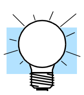
Using Intelligent Output Terminals

The intelligent output terminals are programmable in a similar way to the intelligent input terminals. The inverter has several output functions that you can assign individually to five physical logic outputs. Along with these solid-state outputs, the alarm relay output has type Form C (normally open and normally closed) contacts. The relay is assigned the alarm function by default, but you can assign it to any of the functions that the open-collector outputs can use.

Sinking outputs (open collector)

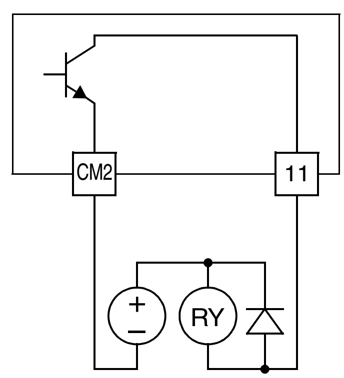


Operations and Monitoring



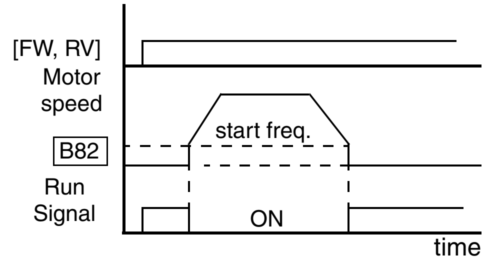
TIP: The open-collector transistor outputs can handle up to 50mA each. We highly recommend that you use an external power source as shown. It must be capable of providing at least 250mA to drive the outputs at full load.

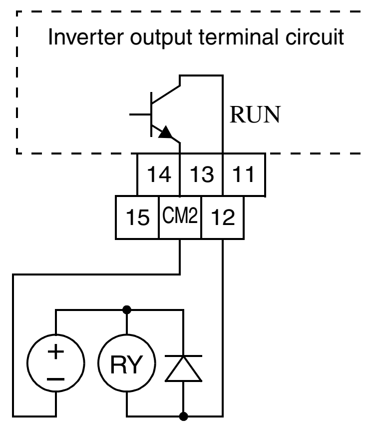
If you need output current greater than 50mA, use the inverter output to drive a small relay. Be sure to use a diode across the coil of the relay as shown (reverse-biased) in order to suppress the turn-off spike, or use a solid-state relay.



Run Signal

When the [RUN] signal is selected as an intelligent output terminal, the inverter outputs a signal on that terminal when it is in Run Mode. The output logic is active low, and is the open collector type (switch to common).



Opt. Code	Symbol	Function Name	Output State	Description
00	RUN	Run signal	ON	when inverter is in Run Mode
			OFF	when inverter is in Stop Mode
Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2			Example: (Default output configuration shown—see page 3–53.)  See I/O specs on page 4–9.
Required settings:	(none)			
Notes: • The inverter outputs the [RUN] signal whenever the inverter output exceeds the start frequency specified by parameter B082. The start frequency is the initial inverter output frequency when it turns ON.				

NOTE: The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter's output transistor.

Frequency Arrival Signals

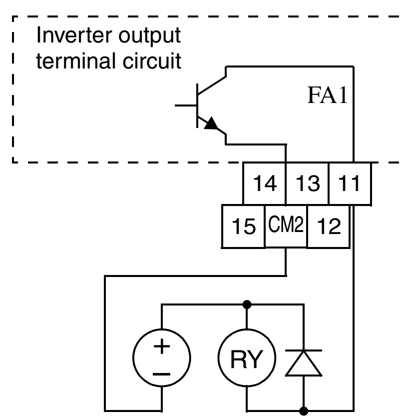
The *Frequency Arrival* group of outputs help coordinate external systems with the current velocity profile of the inverter. As the name implies, output [FA1] turns ON when the output *frequency arrives* at the standard set frequency (parameter F001). Outputs [FA2] through [FA5] provide variations on this function for increased flexibility, relying on two programmable accel/decel thresholds. For example, you can have an output turn ON at one frequency during acceleration, and have it turn OFF at a different frequency during deceleration. All transitions have hysteresis to avoid output chatter if the output frequency is near one of the thresholds.

Opt. Code	Symbol	Function Name	Output State	Description
01	FA1	Frequency arrival type 1 – constant speed	ON	when output to motor is at the standard set frequency F001
			OFF	when output to motor is not at the set frequency F001
02	FA2	Frequency arrival type 2 – over-frequency	ON	when output to motor is at or above the FA threshold 1(C042) during accel
			OFF	when the output to motor is below the FA threshold 1 (C043) during decel
06	FA3	Frequency arrival type 3 – at frequency	ON	when output to motor is at the FA threshold 1 (C042) during accel, or at C043 during decel
			OFF	when the output to motor is not at either the FA threshold 1 (C042) during accel or at C43 during decel
24	FA4	Frequency arrival type 4 – over-frequency (2)	ON	when output to motor is at or above the FA threshold 2 (C045) during accel
			OFF	when the output to motor is below the FA threshold 2 (C046) during decel
25	FA5	Frequency arrival type 5 – at frequency (2)	ON	when output to motor is at the FA threshold 2 (C045) during accel, or at C046 during decel
			OFF	when the output to motor is not at either the FA threshold 2 (C045) during accel or at C046 during decel

Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2
Required settings:	F001, for FA1 C042 & C043, for FA2 & FA3 C045 & C046, for FA4 & FA5

Notes:
- For most applications you will need to use only one or two of the frequency arrival type outputs (see example). However, it is possible assign all five output terminals to output functions [FA1] through [FA5].
- For each frequency arrival threshold, the output anticipates the threshold (turns ON early) by an amount equal to 1% of the maximum frequency set for the inverter.
- The output turns OFF as the output frequency moves away from the threshold, delayed by an amount equal to 2% of the max. frequency.

Example: (Default output configuration shown—see page 3–53.)

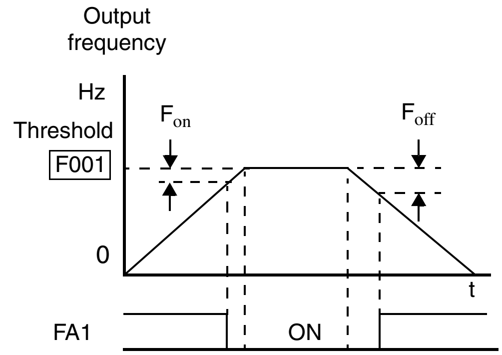


See I/O specs on page 4–9.

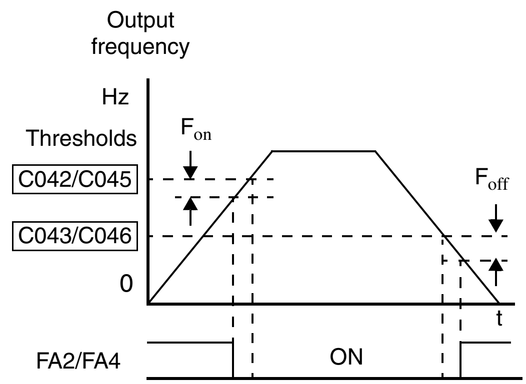
Frequency arrival output [FA1] uses the standard output frequency (parameter F001) as the threshold for switching. In the figure to the right, the inverter accelerates to the set output frequency, which serves as the threshold for [FA1]. Parameters F_{on} and F_{off} illustrate the hysteresis that prevents output chatter near the threshold value.

- F_{on} is 1% of the max. output frequency
- F_{off} is 2% of the max. output frequency

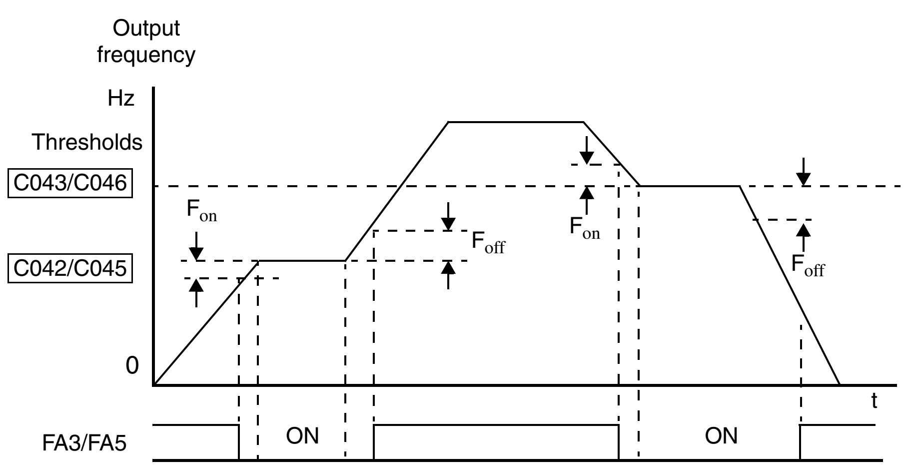
The hysteresis effect causes the output to turn ON slightly *early* as the speed approaches the threshold. Then the turn-OFF point is slightly *delayed*. The 1% and 2% values also apply to the remaining Frequency arrival outputs, discussed below.



Frequency Arrival outputs [FA2] and [FA4] work the same way; they just use two separate threshold pairs as shown in the figure. These provide for separate acceleration and deceleration thresholds to provide more flexibility than for [FA1]. [FA2] uses C042 and C045 for ON and OFF thresholds, respectively. [FA4] uses C043 and C046 for ON and OFF thresholds, respectively. Having different accel and decel thresholds provides an asymmetrical output function. However, you can use equal ON and OFF thresholds, if desired.

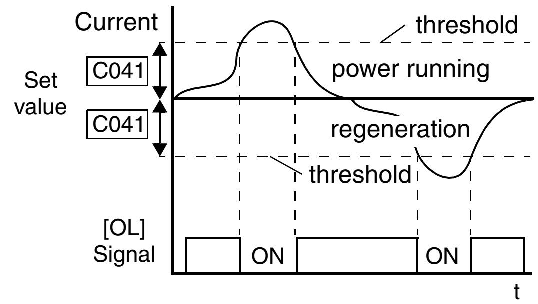


Frequency Arrival outputs [FA3] and [FA5] use the same threshold parameters as [FA2] and [FA4] above, but operate in a slightly different way. Refer to the diagram below. After the frequency arrives at the first threshold during acceleration and turns ON [FA3] or [FA5], they turn OFF again as the output frequency accelerates further. The second thresholds work similarly during deceleration. In this way, we have separate ON/OFF pulses for acceleration and deceleration.

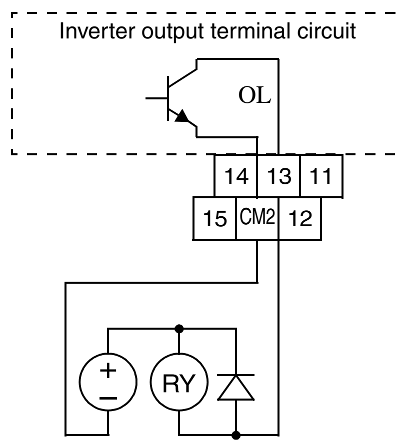


Overload Advance Notice Signal

When the output current exceeds a preset value, the [OL] or [OL2] terminal signal turns ON. The parameter C041 (or C111, respectively) sets the overload threshold. The overload detection circuit operates during powered motor operation and during regenerative braking. The output circuits use open-collector transistors, and are active low.



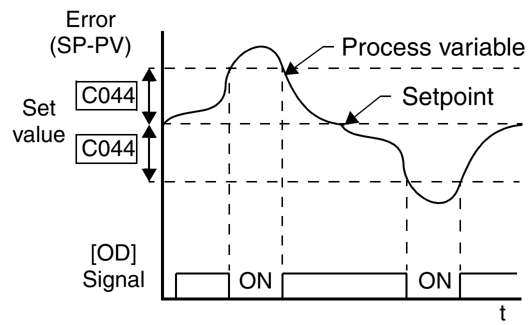
Opt. Code	Symbol	Function Name	Output State	Description
03	OL	Overload advance notice signal (1)	ON	when output current is more than the set threshold for the overload signal (C041)
			OFF	when output current is less than the set threshold for the overload signal (C041)
26	OL2	Overload advance notice signal (2)	ON	when output current is more than the set threshold for the overload signal (C111)
			OFF	when output current is less than the set threshold for the overload signal (C111)

<table>
<tr><td>Valid for outputs:</td><td>11, 12, 13, 14, 15, AL0 – AL2</td><td rowspan="3">Example: (Default output configuration shown—see page 3–53.)

See I/O specs on page 4–9.</td></tr>
<tr><td>Required settings:</td><td>C041, C111</td></tr>
<tr><td colspan="2">Notes:
• The default value is 100%. To change the level from the default, set C041 or C111(overload level).
• The accuracy of this function is the same as the function of the output current monitor on the [FM] terminal (see “Analog Output Operation” on page 4–62).</td></tr>
</table>

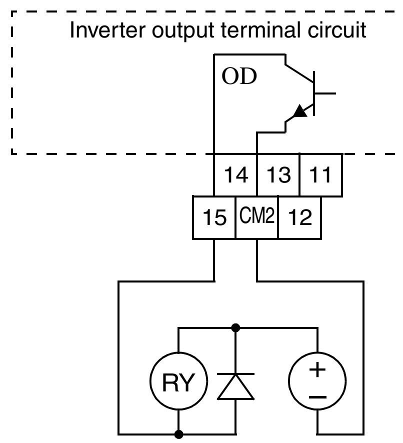
NOTE: The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter’s output transistor.

Output Deviation for PID Control

The PID loop error is defined as the magnitude (absolute value) of the difference between the Setpoint (target value) and the Process Variable (actual value). When the error magnitude exceeds the preset value for C044, the [OD] terminal signal turns ON. Refer to “PID Loop Operation” on page 4–71.



Opt. Code	Symbol	Function Name	Output State	Description
04	OD	Output deviation for PID control	ON	when PID error is more than the set threshold for the deviation signal
			OFF	when PID error is less than the set threshold for the deviation signal

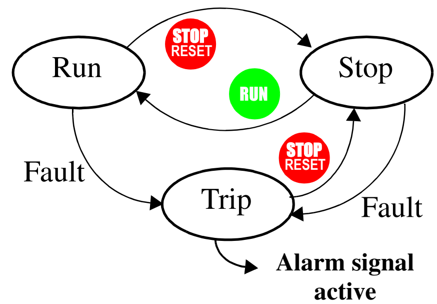
Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2	Example: (Requires output configuration—see page 3–53):
Required settings:	C044	
Notes: • The default deviation value is set to 3%. To change this value, change parameter C044 (deviation level).		 See I/O specs on page 4–9.

NOTE: The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter’s output transistor.

Operations and Monitoring

Alarm Signal

The inverter alarm signal is active when a fault has occurred and it is in the Trip Mode (refer to the diagram at right). When the fault is cleared the alarm signal becomes inactive.



We must make a distinction between the alarm *signal* AL and the alarm relay *contacts* [AL0], [AL1] and [AL2]. The signal AL is a logic function, which you can assign to the open collector output terminals [11] to [15], or the relay outputs. The most common (and default) use of the relay is for AL, thus the labeling of its terminals. Use an open collector output (terminals [11] to [15]) for a low-current logic signal interface or to energize a small relay (50 mA maximum). Use the relay output to interface to higher voltage and current devices (10 mA minimum).

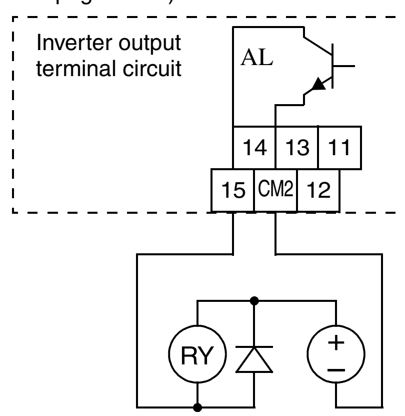
Opt. Code	Symbol	Function Name	Output State	Description
05	AL	Alarm signal	ON	when an alarm has occurred and has not been cleared
			OFF	when no alarm has occurred since the last clearing of alarm(s)

Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2
Required settings:	C026, C036

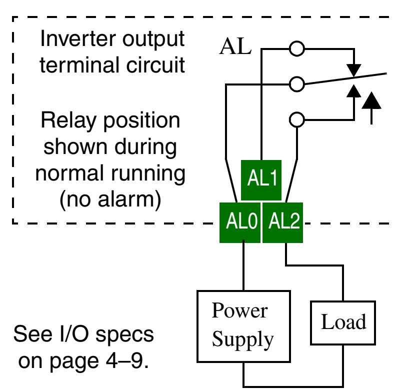
Notes:

- When the alarm output is set to normally closed, a time delay of less than 2 seconds occurs until the contact is closed when the power is turned ON.
- Terminals [11] – [15] are open collector outputs, so the electrical specifications of [AL] are different from the contact output terminals [AL0], [AL1], [AL2].
- When the inverter power supply is turned OFF, the alarm signal output is valid as long as the external control circuit has power.
- This signal output has the delay time (300ms nominal) from the fault alarm output.
- The relay contact specifications are in “Specifications of Control and Logic Connections” on page 4–9. The contact diagrams for different conditions are on the next page.

Example for terminals [11] to [15]: (Requires output configuration—see page 3–53.)

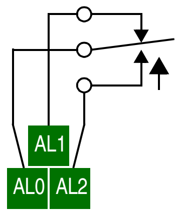
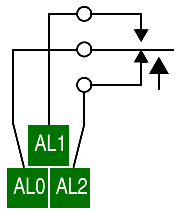
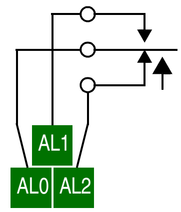
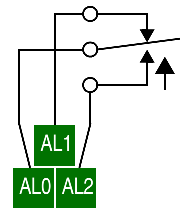


Example for terminals [AL0], [AL1], [AL2]: (Default output configuration shown—see page 3–53.)



See I/O specs on page 4–9.

The alarm output terminals operate as shown below (left) by default. The contact logic can be inverted as shown (below right) by using the parameter setting C036. The relay contacts normally open (N.O.) and normally closed (N.O.) convention uses "normal" to mean the inverter has power and is in Run or Stop Mode. The relay contacts switch to the opposite position when it is in Trip Mode or when input power is OFF.

N.C. contacts (after initialization)		N.O. contact (inverted by C036 setting)	
During normal running	When an alarm occurs or power is turned OFF	During normal running or power is turned OFF	When an alarm occurs
			

Contact	Power	Run State	AL0-AL1	AL0-AL2
N.C. (after initialize, C036=01)	ON	Normal	Closed	Open
	ON	Trip	Open	Closed
	OFF	–	Open	Closed

Contact	Power	Run State	AL0-AL1	AL0-AL2
N.O. (set C036=00)	ON	Normal	Open	Closed
	ON	Trip	Closed	Open
	OFF	–	Open	Closed

Over-torque Signal

The Over-torque function [OTQ] turns ON when the estimated value of output torque of motor increases more than the arbitrary level set for the output. Recall that the torque limit function, covered in “Torque Limit” on page 4–37, actually limits the torque during certain operating conditions. Instead, the over-torque output feature only monitors the torque, turning ON output [OTQ] if the torque is above programmable thresholds you set. The [OTQ] function is valid only for sensorless vector control, 0-Hz domain sensorless vector control, or vector control with sensor. Do not use the [OTQ] output, except for these inverter operational modes.

Code	Function/Description	Data or Range
C055	Over-torque, forward-driving level setting	0 to 200%
C056	Over-torque, reverse-regenerating, level setting	0 to 200%
C057	Over-torque, reverse-driving, level setting	0 to 200%
C058	Over-torque, forward-regenerating, level setting	0 to 200%
C021 to C025	Intelligent output terminal [11] to [15] function	07

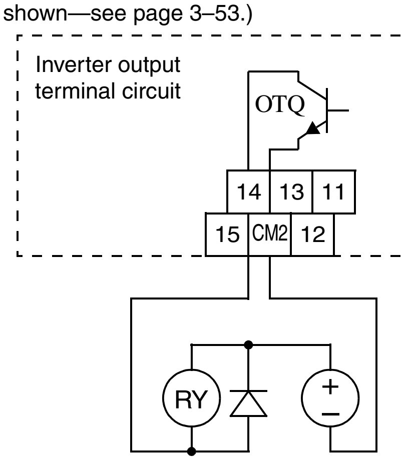
The assignment of the Over-torque function to an output terminal [OTQ] is detailed in the following table.

Opt. Code	Symbol	Function Name	Output State	Description
07	OTQ	Over-torque	ON	when estimated torque exceeds the level set in C055 to C058
			OFF	when estimated torque is below the levels set in C055 to C058

Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2	Example: (Default output configuration shown—see page 3–53.)
Required settings:	C055, C056, C057, C058 A044 = 03 or 04 or 05	

Notes:

- This output is valid only for sensorless vector control, 0-Hz domain sensorless vector control, or vector control with sensor



See I/O specs on page 4–9.

Instantaneous Power Failure / Under-voltage Signal

An instantaneous power failure (complete loss) or under-voltage condition (partial loss) of inverter input voltage can occur without warning. SJ300 Series inverters can be configured to respond to these conditions in different ways. You can select whether the inverter trips or retries (restart attempt) when an instantaneous power failure or under-voltage condition occurs. You can select the retry function with parameter B001.

When enabled, the Retry Function operates in the following ways:

- **Under-voltage conditions** – When an instantaneous power failure or under-voltage condition occurs, the inverter will attempt to restart up to 16 times. A trip condition will occur on the 17th attempt, which must be cleared with the Stop/Reset key.
- **Over-current/voltage conditions** – When retry function is selected and an over-current or an over-voltage condition occurs, a restart is attempted 3 times. A trip will occur on the 4th failed restart attempt. Use parameter B004 to select the trip and alarm response to instantaneous power failure and under-voltage conditions. The following table shows the related parameters to these power fault conditions, and timing diagrams are on the next page.

Code	Function	Data or Range	Description
B001	Selection of automatic restart mode	00	Alarm output after trip, automatic restart disabled
		01	Restart at 0 Hz
		02	Retry with frequency matching to present motor speed
		03	Retry with frequency matching followed by deceleration to stop—then trip alarm
B002	Allowable under-voltage power failure time	0.3 to 1.0 sec.	The amount of time a power input under-voltage can occur without tripping the power failure alarm. If under-voltage exists longer than this time, the inverter trips, even if the restart mode is selected. If it exists less than this time retry will be attempted.
B003	Retry wait time before motor restart	0.3 to 100 sec.	Time delay after a trip condition goes away before the inverter restarts the motor
B004	Instantaneous power failure / voltage trip alarm enable	00	Disable
		01	Enable
		02	Disable during stop and ramp to stop
B005	Number of restarts on power failure / under-voltage trip events	00	Restart up to 16 times on instantaneous power failure or under-voltage
		01	Always restart on instantaneous power failure or an under-voltage condition
B007	Restart frequency threshold	0.00 to 400.0 Hz	When frequency of the motor is less than this value, the inverter will restart at 0 Hz

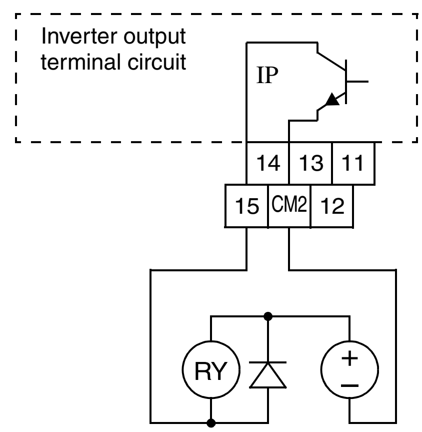
Opt. Code	Symbol	Function Name	Output State	Description
08	IP	Instantaneous Power Failure	ON	when the inverter detects a loss of input power
			OFF	when the inverter has input power
09	UV	Under-voltage condition	ON	when the inverter input power is less than the specified input range
			OFF	when the inverter input power is within the voltage specification

Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2
Required settings:	B001, B002, B003, B004, B005, B007

Notes:

- If an over-voltage or over-current trip occurs during the deceleration and an instantaneous power failure error (E16) is displayed the inverter goes into free-run stop. In this case make the deceleration time longer.
- When connecting control power supply terminals [Ro]-[To] to the DC bus [P]-[N], an under-voltage may be detected at power-off and cause a trip. If this is undesirable, set B004 to 00 or 02.
- Frequency matching: The inverter reads the motor RPM and direction. If this speed is higher than the matching setting (B007), the inverter waits until they are equal and then engages the output to drive the motor (example 3). If the actual motor speed is less than the restart frequency setting, the inverter waits for t_2 (value in B003) and restarts from 0 Hz (example 4). The display shows "0000" during an actual frequency matching event.

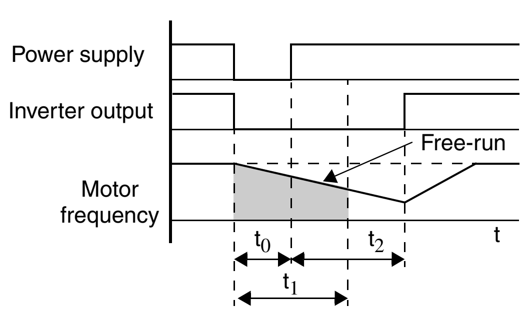
Example: (Default output configuration shown—see page 3–53.)



See I/O specs on page 4–9.

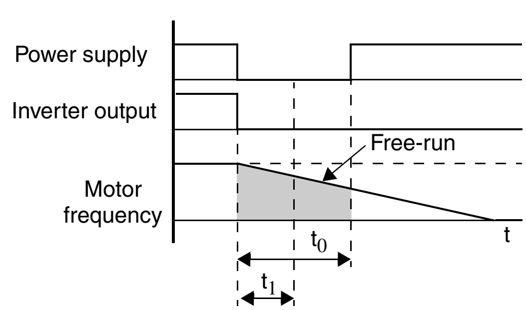
In the following examples, t_0= instantaneous power failure time, t_1 = allowable under-voltage / power failure time (B002), and t_2= retry wait time (B003).

Example 1: Power failure within allowed limits; resume



After waiting for t_2 seconds when $t_0 < t_1$; restart

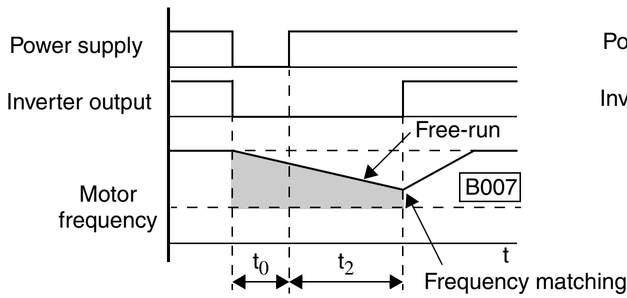
Example 2: Power failure longer than limits; trip



Inverter trips when $t_0 > t_1$

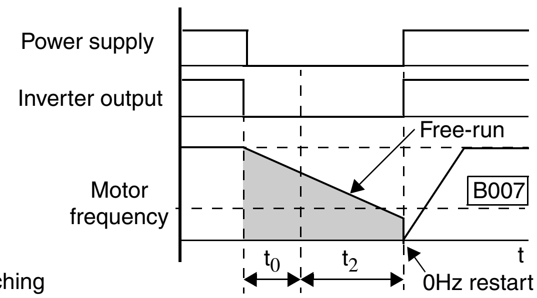
Examples 3 and 4 relate to configuring the inverter to retry upon power failure. Frequency matching is possible if the inverter frequency is greater than the B007 value.

Example 3: Motor resumes via frequency-matching



Motor frequency > B007 value at t_2

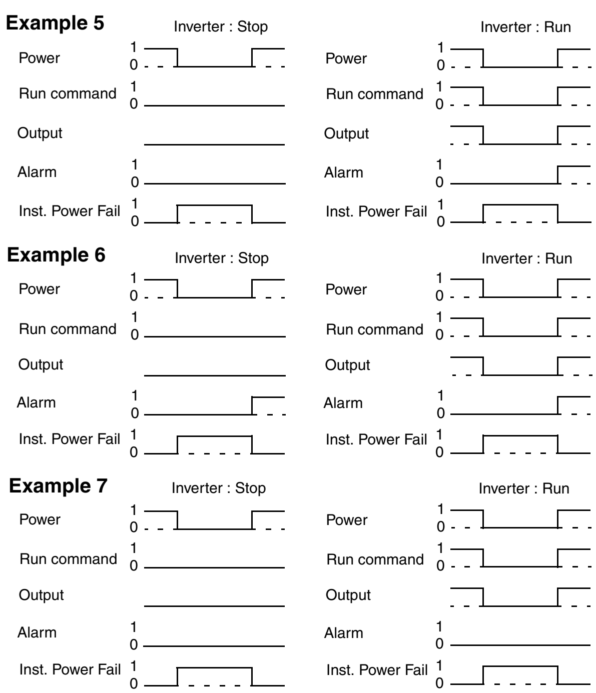
Example 4: Motor restarts from 0Hz



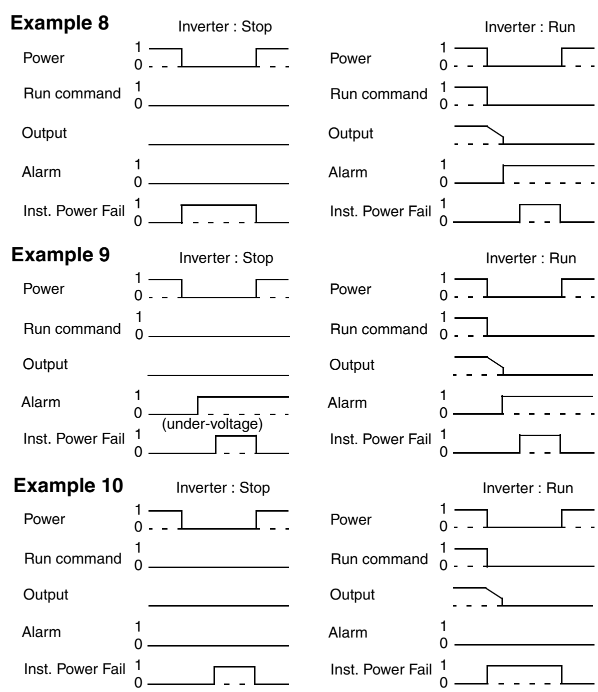
Motor frequency < B007 value at t_2

The Instantaneous Power Failure and Alarm output responses during various power loss conditions are shown in the diagram below. Use B004 to enable/disable the alarm output when instantaneous power failure or under-voltage occurs. The alarm output will continue while the control power of the inverter is present, even if the motor is stopped. Examples 5 to 7 correspond to normal wiring of the inverter's control circuit. Examples 8 to 10 correspond to the wiring of the inverter's control circuit for controlled deceleration after power loss (see "Optional Controlled Decel and Alarm at Power Loss" on page 4–4).

Instantaneous power failure operation with standard R0–T0 connections



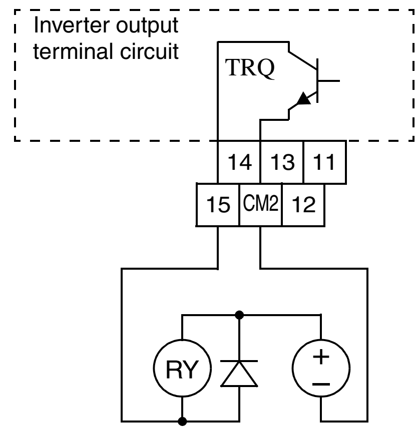
Instantaneous power failure operation with R0–T0 connected to P–N



Torque Limit Signal

The Torque Limit output [TRQ] works in conjunction with the torque limit function covered in the intelligent input section. The torque limit function limits the motor torque according to the criteria selected by parameter B040. When torque limiting occurs, the [TRQ] output turns ON, then going OFF automatically when the output torque falls below the specified limits. See “Torque Limit” on page 4–37 in the intelligent input section.

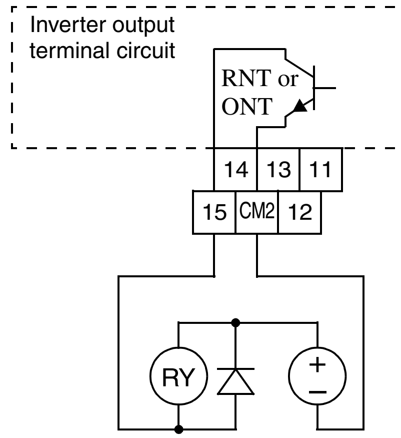
Opt. Code	Symbol	Function Name	Output State	Description
10	TRQ	Torque Limit	ON	when the inverter is limiting torque
			OFF	when the inverter is not limiting torque

<table>
<tr><td>Valid for outputs:</td><td>11, 12, 13, 14, 15, AL0 – AL2</td><td rowspan="3">Example: (Requires output configuration—see page 3–53.)

See I/O specs on page 4–9.</td></tr>
<tr><td>Required settings:</td><td>B040... if B040=00 then B041, B042, B043, B044 are required</td></tr>
<tr><td colspan="2">Notes:
• The Torque Limit input [TL] must be ON in order to enable torque limiting and its related output, [TRQ].</td></tr>
</table>

Run Time / Power-On Time Over Signals

SJ300 Series inverters accumulate the total hours in Run Mode (run time) and the total hours of power-ON time. You can set thresholds for these accumulating timers. Once the threshold is exceeded, an output terminal will turn ON. One use of this is for preventative maintenance. A signal light or audible alert could signal the need for servicing, calibration, etc.

Opt. Code	Symbol	Function Name	Output State	Description
11	RNT	Run Time Over	ON	when the accumulated time spent in Run Mode exceeds the limit (B034)
			OFF	when the accumulated time in Run Mode is still less than the limit (B034)
12	ONT	Power-ON Time Over	ON	when the accumulated power-ON time exceeds the limit (B034)
			OFF	when the accumulated power-ON time is less than the limit (B034)

Opt. Code	Symbol	Function Name	Output State	Description
Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2			Example: (Requires output configuration—see page 3–53.)  See I/O specs on page 4–9.
Required settings:	B034			
Notes: • The two outputs [RNT] and [ONT] share the same time threshold parameter, B040. Typically, you will use either the [RNT] or the [ONT] output only—not both at once. • These outputs are useful for the notification that a preventative maintenance interval has expired.				

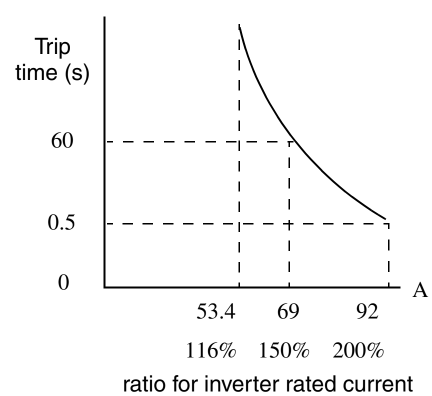
Thermal Warning Signal

The purpose of the electronic thermal setting is to protect the motor from overloading, overheating and being damaged. The setting is based on the rated motor current. The inverter calculates the thermal rise (heating) of the motor using the current output to the motor squared, integrated over the time spent at those levels. This feature allows the motor to draw excessive current for relatively short periods of time, allowing time for cooling.

The Thermal Warning output [THM] turns ON to provide a warning before the inverter trips for electronic thermal protection. You can set a unique thermal protection level for each of the three motor profiles, as shown in the table below.

Function Code	Function/Description	Data or Range
B012 / B212 / B312	Electronic thermal setting (calculated within the inverter from current output)	Range is 0.2 * rated current to 1.2 * rated current

For example, suppose you have inverter model SJ300-110LFE. The rated motor current is 46A. The setting range is (0.2 * 46) to (1.2 *46), or 9.2A to 55.2A. For a setting of B012=46A (current at 100%), the figure to the right shows the curve.



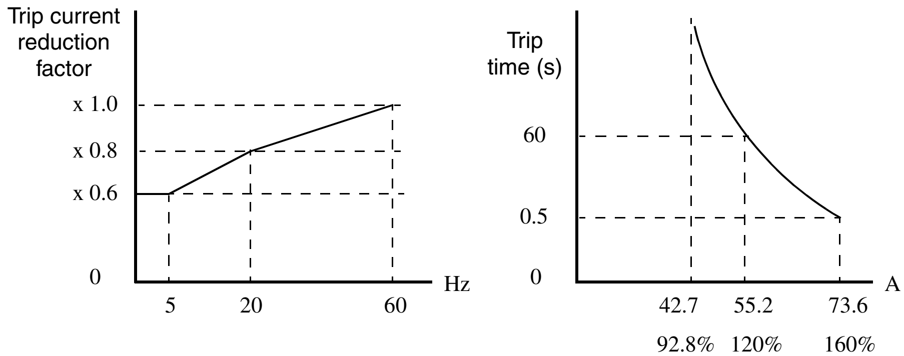
The electronic thermal characteristic adjusts the way the inverter calculates thermal heating, based on the type of torque control the inverter uses.

CAUTION: When the motor runs at lower speeds, the cooling effect of the motor's internal fan decreases.

The table below shows the settings and their meanings. Use the one that matches your load.

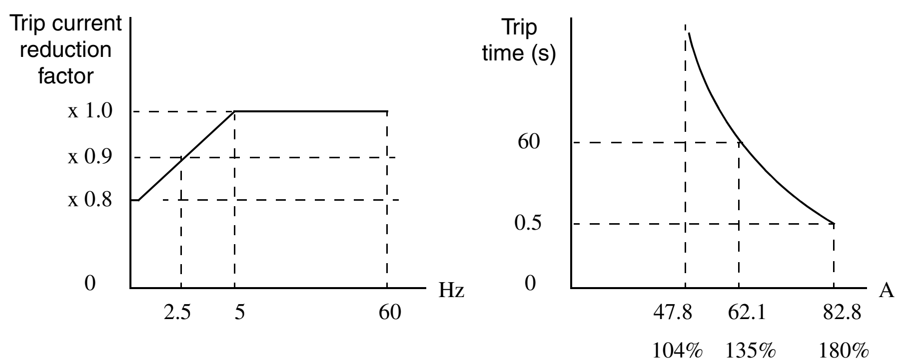
Function Code	Data	Function/Description
B013 / B213 /B313	00	Reduced torque
	01	Constant torque
	02	Free-setting

Reduced Torque Characteristic – The example below shows the effect of the reduced torque characteristic curve (for example motor and current rating). At 20Hz, the output current is reduced by a factor of 0.8 for given trip times.



Reduced trip current at 20 Hz

Constant Torque Characteristic – Selecting the constant torque characteristic for the example motor gives the curves below. At 2.5 Hz, the output current is reduced by a factor of 0.9 for given trip times.

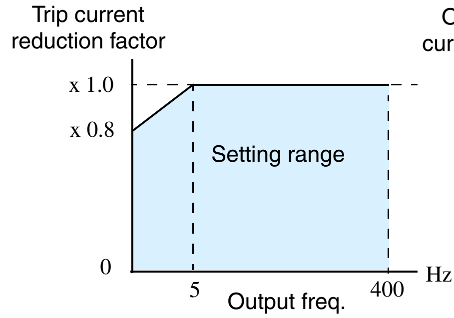


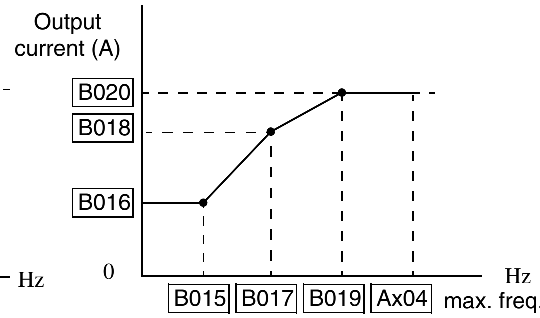
Reduced trip current at 2.5 Hz

Free Thermal Characteristic - It is possible to set the electronic thermal characteristic using a free-form curve defined by three data points, according to the table below.

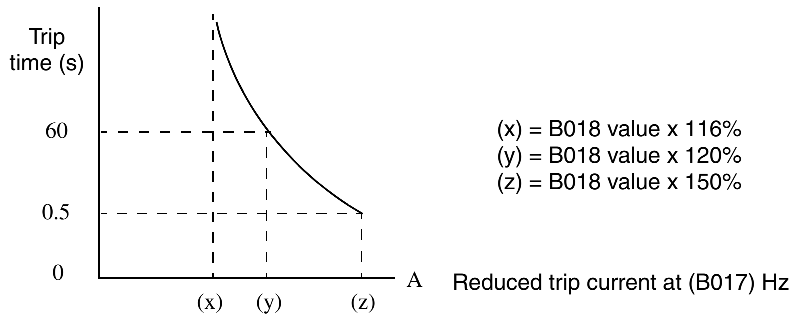
Function Code	Name	Description	Range
B015 / B017 / B019	Free-setting electronic thermal frequency 1, 2, 3	Data point coordinates for Hz axis (horizontal) in the free-form curve	0 to 400Hz
B016 / B018 / B020	Free setting electronic thermal current 1, 2, 3	Data point coordinates for Ampere axis (vertical) in the free-form curve	0.0 = (disable) 0.1 to 1000.

The left graph below shows the region for possible free-setting curves. The right graph below shows an example curve defined by three data points specified by B015 – B020.





Suppose the electronic thermal setting (B012) is set to 44 Amperes. The graph below shows the effect of the free setting torque characteristic curve. For example, at (B017) Hz, the output current level to cause overheating in a fixed time period is reduced to (B018) A. Points (x), (y), and (z) show the adjusted trip current levels in those conditions for given trip times.



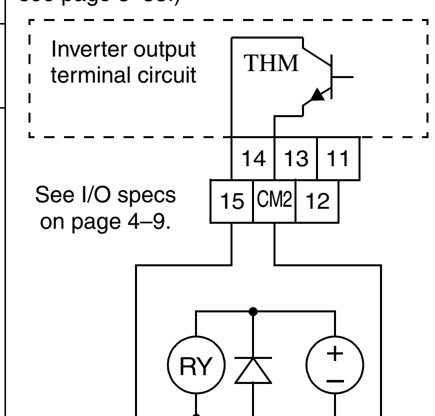
Thermal Warning Output – Using parameter C061, you can set the threshold from 0 to 100% of trip level for turning ON the intelligent output [THM] at that level. In this way, the inverter provides an early warning before the electronic thermal overload trips and turns OFF the output to the motor.

Opt. Code	Symbol	Function Name	Output State	Description
13	THM	Thermal Warning	ON	when the electronic thermal calculation exceeds the set limit
			OFF	when the electronic thermal calculation is less than the set limit

Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2	Example: (Requires output configuration—see page 3–53.)
Required settings:	C061	

Notes:

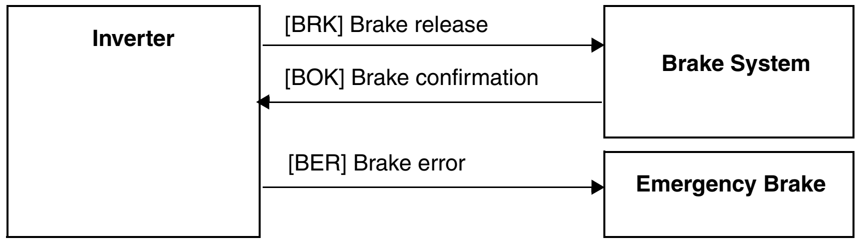
- The electronic thermal overload function uses the output current and time to calculate thermal heating of the motor.
- The thermistor input of the inverter is a separate function from the electronic thermal function. You can set a threshold for it to cause a trip alarm at a particular thermistor resistance.



Operations and Monitoring

Brake Control Signals

The Brake Control function enables the inverter to control external braking systems with a particular safety characteristic. A complete discussion of the operation of brake control is in “External Brake Control Function” on page 4–39. The block diagram and table that follow describe the configuration of the outputs [BRK] Brake Release and [BER] Brake Error.



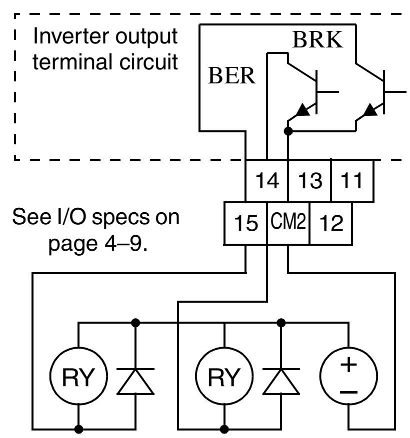
Opt. Code	Symbol	Function Name	Output State	Description
19	BRK	Brake Release	ON	when the inverter signals the external brake system to release (open) its brake
			OFF	when the inverter is not driving the motor, and needs the external brake engaged
20	BER	Brake Error	ON	when the output current is less than the set releasing current
			OFF	when the brake function is not in use, or when the output current to the motor is correct and it is safe to release the brake

Valid for outputs:	11, 12, 13, 14, 15, AL0 – AL2
Required settings:	B120, B121, B122, B123, B124, B125, B126

Notes:

- The brake release logic convention is such that an open circuit fault (such as loose wire) causes the external brake to engage.

Example: (Requires output configuration—see page 3–53.)



Expansion Card Output Signals

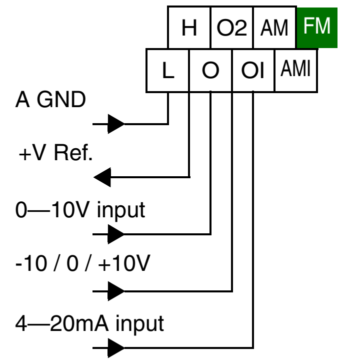
Other outputs listed below require expansion card SJ-FB Encoder Feedback board. Please see the SJ-FB manual for more information.

Opt. Code	Symbol	Function Name	Description
21	ZS	Zero Speed Detect signal	Signal indicates the encoder pulses of the motor have stopped
22	DSE	Speed Deviation Excessive	Velocity error exceeds the error threshold defined by parameter P26
23	POK	Positioning Completion	Indicates the load position is at the target

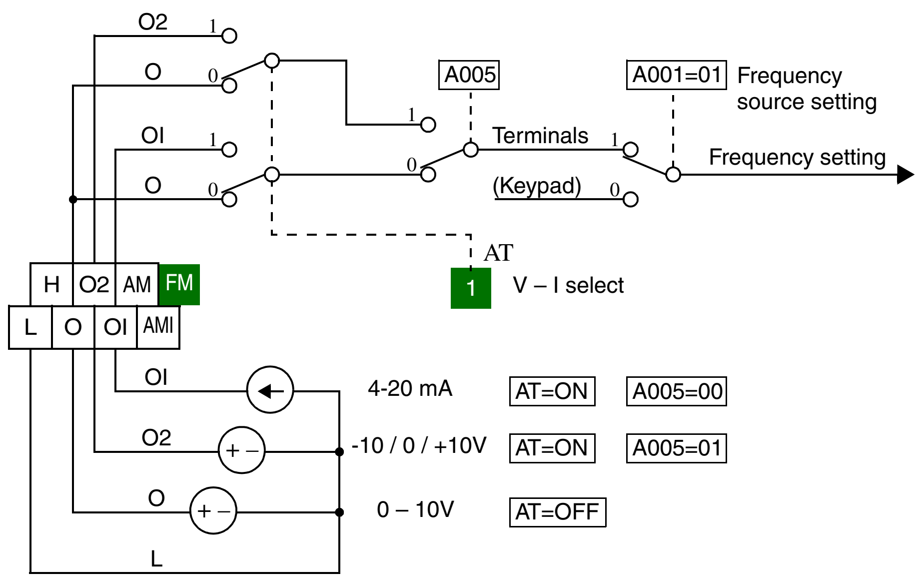
Analog Input Operation

Input Terminal Signals

The SJ300 inverters provide for an external analog input to command the inverter frequency output value. The analog input terminal group includes the [L], [OI], [O], [O2], and [H] terminals on the control connector, which provide for Voltage [O] and [O2] or Current [OI] input. All analog input signals must use the analog ground [L].



If you use either the voltage or current analog input, you must select one of them using the logic input terminal function [AT] analog type. If terminal [AT] is OFF, the voltage input [O] can command the inverter output frequency. If terminal [AT] is ON, the current input [OI] can command the inverter output frequency. The [AT] terminal function is covered in “Analog Input Current/ Voltage Select” on page 4–26. Remember that you must also set A001 = 01 to select analog input as the frequency source.



Input Filter

Parameter A016 adjusts an analog input sampling filter that evenly affects all analog inputs shown above. The parameter range is from 1 to 30. Before increasing the filter setting, we recommend trying to find the cause of input analog noise. Check for the following:

- Look for nearby high-current wiring—avoid any parallel runs to the analog signal wires
- Check the impedance between the chassis grounds of the inverter and the analog signal source equipment—a good connection will have a low impedance
- Check the analog signal ground impedance from the inverter to the analog signal source
- Avoid ground loops... measure the current (or voltage drop) on the chassis ground and signal ground connections; the ideal value is zero

After taking steps to minimize the analog signal noise sources, increase the filter time constant (A016) until the motor output frequency (when commanded by analog inputs) becomes stable.

The following tables show the available analog input settings. Parameters A006, A005, and input terminal [AT] determine the External Frequency Command input terminals that are available and how they function. The Trim Frequency input [O2]—[L] is available (when check marked) for some settings. Other settings make the reverse direction (in addition to forward) available for bipolar input settings (when check marked). A bipolar input responds to positive input voltages with a forward motor rotation, and to negative input voltages with reverse motor rotation.

A006	A005	[AT]	External Frequency Command Input	Trim Frequency Command Input	Reverse avail. (bipolar input)
00	00	OFF	[O]	✘	✘
		ON	[OI]	✘	✘
	01	OFF	[O]	✘	✘
		ON	[O2]	✘	✔
01	00 Example 1	OFF	[O]	[O2]	✘
		ON	[OI]	[O2]	✘
	01	OFF	[O]	[O2]	✘
		ON	[O2]	✘	✔
02	00 Example 2	OFF	[O]	[O2]	✔
		ON	[OI]	[O2]	✔
	01	OFF	[O]	[O2]	✔
		ON	[O2	✘	✔

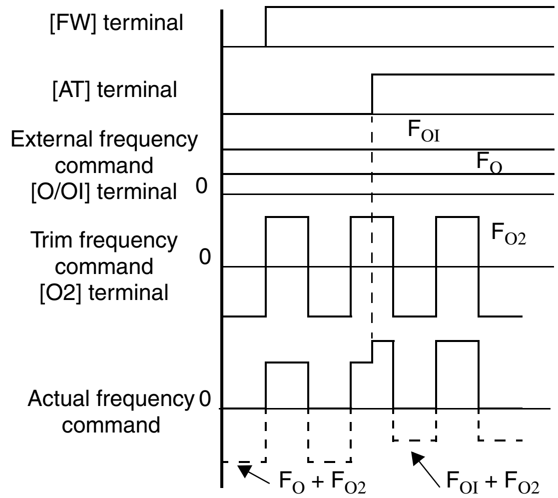
The table below applies when the [AT] input function is not assigned to *any* intelligent input terminal. The A005 setting, normally used in conjunction with an [AT] input, is ignored.

A006	A005	[AT]	External Frequency Command Input	Trim Frequency Command Input	Reverse avail. (bipolar input)
00	—	(not assigned to any input terminal)	[O2]	✘	✔
01	—		Summation of [O] and [OI]	[O2]	✘
02	—		Summation of [O] and [OI]	[O2]	✔

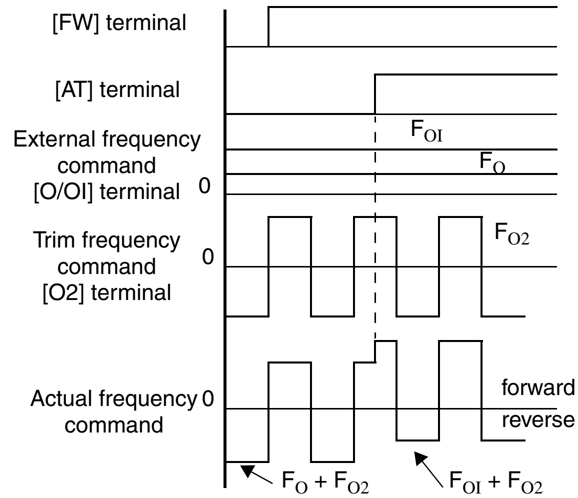
CAUTION: Whenever the [AT] input function is *not* assigned to any input terminal and reverse rotation is not desired or is unsafe, be sure to set A006 = 01. This setting makes the [O2] input unipolar only.

The examples below show how the use of the [AT] input during operation enables/disables the Trim Frequency Command input [O2]—[L]. The [O2]—[L] input may be used alone, or as an offset control for the primary analog input.

Example 1: Without reverse

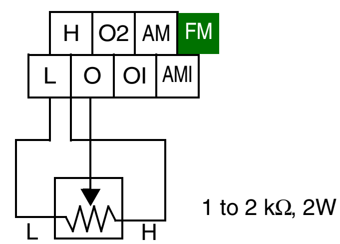


Example 2: With reverse



Wiring Examples

Using an external potentiometer is a common way to control the inverter output frequency (and a good way to learn how to use the analog inputs). The potentiometer uses the built-in 10V reference [H] and the analog ground [L] for excitation, and the voltage input [O] for the signal. By default, the [AT] terminal selects the voltage input when it is OFF. Take care to use the proper resistance for the potentiometer, which is 1 to 2kΩ, 2 Watts.

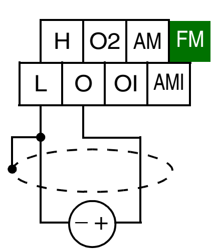


Voltage Input – The 0–10V voltage input circuit uses terminals [L] and [O]. Attach the signal cable's shield wire to terminal [L] on the inverter only. DO NOT ground the shield at its other end. Maintain the voltage within specifications (do not apply negative voltage). Normally a full-span input level (10V) will give the maximum motor frequency. You can use parameter A014 to select a lower voltage for full output frequency (such as using a 5V input signal).

Bipolar Voltage Input – The -10 / 0 / +10V voltage input circuit uses terminals [L] and [O2]. Attach the cable's shield wire to terminal [L] on the inverter only. Maintain the voltage within specifications. Only apply a negative voltage if this input is configured for bipolar use.

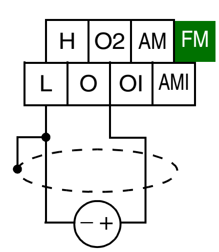
Current Input – The current input circuit uses terminals [OI] and [L]. The current comes from a *sourcing* type transmitter; a *sinking* type will not work! This means the current must flow into terminal [OI], and terminal [L] is the return back to the transmitter. The input impedance from [OI] to [L] is 250 Ohms. Attach the cable's shield wire to terminal [L] on the inverter only.

Standard Voltage Input



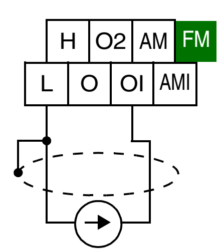
0 to 9.6 VDC,
0 to 10V nominal

Bipolar Voltage Input



-10 to 9.6 VDC,
0 to 10V nominal

Current Input



4 to 19.6 mA DC,
4 to 20 mA nominal

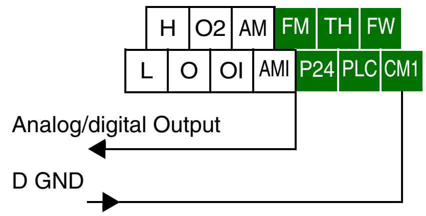
See I/O specs on page 4–9.

Analog Output Operation

In the system design for inverter applications it is sometimes useful to monitor inverter operation from a remote location. In some cases, this requires only a panel-mounted analog meter (moving-coil type). In other cases, a controller device such as a PLC may monitor and command the inverter frequency and other functions. The inverter can transmit the (real-time) output frequency, current, torque, or other parameters to the controller to confirm actual operation. The monitor output terminal [FM] serves these purposes.

[FM] Terminal

The inverter provides an analog/digital output on terminal [FM] (frequency monitor). It uses terminal [CM1] as digital GND reference. While many applications use this terminal to monitor the output frequency, you can configure terminal [FM] to transmit one of several parameters. Most use *pulse-width modulation* (PWM) to represent the value, while one parameter uses *frequency modulation* (FM) to represent the value. Do not confuse the notation for terminal [FM] (with brackets) with FM signal type.



See I/O specs on page 4–9.

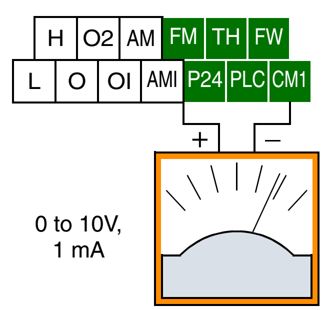
The following table lists the configurations for terminal [FM]. Use function C027 to configure.

Func.	Code	Description	Waveform	Full Scale Value
C027	00	Output frequency	PWM	0 – Max. frequency (Hz)
	01	Output current	PWM	0 – 200%
	02	Output torque *1	PWM	0 – 200%
	03	Output frequency	FM	0 – Max. frequency (Hz)
	04	Output voltage	PWM	0 – 100%
	05	Input electric power	PWM	0 – 200%
	06	Thermal load ratio	PWM	0 – 100%
	07	LAD frequency	PWM	0 – Max. frequency (Hz)

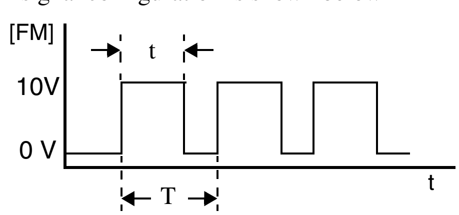
Note 1: Display substitutes only during sensorless vector control, 0Hz domain sensorless vector control, and vector control

PWM Signal Type

The *pulse-width modulated* signal at terminal [FM] is primarily designed for driving a moving-coil meter. The pulse-width modulated signal is automatically averaged by the inertia of the moving-coil mechanism—converting the PWM signal to an analog representation. Be sure to use a 10V full-scale DC voltmeter.



The signal characteristics of terminal [FM] in PWM signal configuration is shown below



Period T = 6.4ms constant (156 Hz)

$$\text{[FM] output value} = \frac{t}{T}$$

B081 = [FM] terminal 8-bit gain setting

C27=00, 01, 02, 04, 05, 06, 07

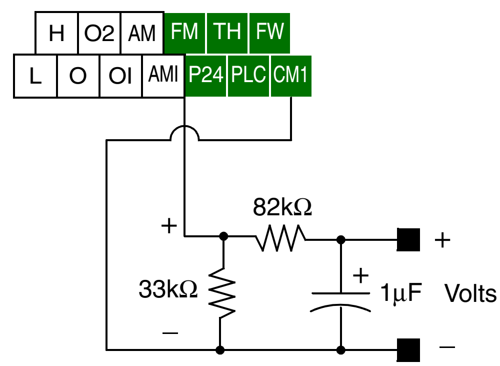
Selects FM type output

To calibrate the meter reading, generate a full-scale output (always ON) at terminal [FM]. Then use parameter B081(gain setting from 0 to 255) to adjust the corresponding full-scale reading of the meter. For example, when the inverter output frequency is 60 Hz, change the value of B081 so that the meter reads 60 Hz.

TIP: When using the analog meter for monitoring, adjust the meter so it has a zero reading when the [FM] output is zero. Then use scale factor B081 to adjust the [FM] output so the maximum frequency in the inverter corresponds to a full-scale reading on the meter.

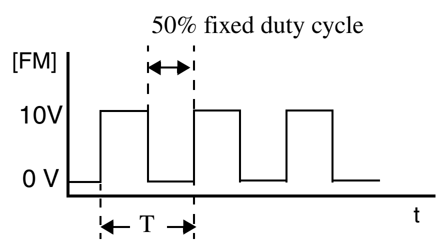
NOTE: The indicator accuracy after adjustment is about ±5%. Depending on the motor, the accuracy may exceed this value.

PWM Smoothing Circuit – Note that standard analog output signals are available on terminals [AM] and [AMI], covered in the next section. However, you may also wish to smooth the PWM signal at the [FM] terminal and convert it to an analog signal. The [FM] terminal will then generate a relatively stable DC analog voltage that represents the output value. To do this, use the circuit shown to the right. Note the output impedance of the circuit is at least 82kΩ, so the monitoring device needs an input impedance of 1MΩ or greater. Otherwise, the impedance of the smoothing circuit will cause a nonlinearity in the reading.



FM Signal Type

The *frequency-modulated* output at terminal [FM] varies its frequency with the inverter output frequency (C027=03). The multiplier is 10, such that the maximum [FM] signal frequency is 10 x 400 = 4 kHz, or 10 times the inverter's maximum output frequency. The signal at [FM] uses the parameter A004 *Maximum frequency setting*. For example, if A004 = 60 Hz, then the maximum signal value at [FM] will be 10 x 60 = 600 Hz. This frequency is digitally controlled for accuracy, and does not use the B081 gain setting when C027=03 (frequency modulation).



$$T = \frac{1}{[FM]\text{ Output value} \times 10}$$

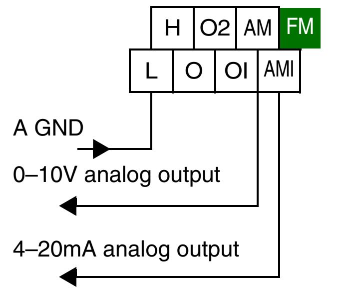
$$[FM]\text{ Output value} = \frac{1}{T \times 10}$$

C027=03 Selects FM type output

[AM] and [AMI] Terminals

The [AM] and [AMI] terminals provide signals to monitor various inverter parameters such as output frequency, output current, and torque. The terminals provide these analog signal types:

- [AM] terminal: 0–10V analog output signal
- [AMI] terminal: 4–20mA analog output signal



See I/O specs on page 4–9.

These signals both use the [L] terminal for signal return. Eight different inverter parameters may be monitored independently at either the [AM] or [AMI] terminal, as listed in the table below. Use C028 to configure terminal [AM], and C029 to configure terminal [AMI].

Func.	Terminal	Code	Description	Full Scale Value
C028 / C029	[AM] / [AMI]	00	Output frequency	0 – Max. frequency (Hz)
		01	Output current	0 – 200%
		02	Output torque *1	0 – 200%
		04	Output voltage	0 – 100%
		05	Input electric power	0 – 200%
		06	Thermal load ratio	0 – 100%
		07	LAD frequency	0 – Max. frequency (Hz)

Note 1: Display of torque is possible only during sensorless vector control, 0Hz domain sensorless vector control, and vector control with feedback

The analog signals may need some adjustment for gain or offset to compensate for variances in the system. For example, the signals may drive a panel meter and require a full-scale gain adjustment. The table below lists the function codes and their descriptions. The [AM] and [AMI] terminals have separate gain and offset adjustments. Note the default values.

Func.	Terminal	Description	Range	Default
B080	[AM]	Gain adjustment	0 – 255	180
C086	[AM]	Offset Adjustment	0.0 – 10.0V	0.0V
C087	[AMI]	Gain adjustment	0 – 255	80
C088	[AMI]	Offset Adjustment	0.0 – 20.0mA	0.0mA

Setting Motor Constants for Vector Control

Introduction

These advanced torque control algorithms improve performance, particularly at low speeds:

- **Sensorless Vector Control –** improved torque control at output frequencies down to 0.5 Hz. Use A044=03 (1st motor) or A244=03 (2nd motor) to select sensorless vector control.
- **Sensorless Vector Control, 0Hz Domain –** improved torque control at output frequencies from 0 to 2.5 Hz. Use A044=04 (1st motor) or A244=04 (2nd motor) to select sensorless vector control, 0Hz domain.
- **Sensorless Vector Control with Feedback –** improved torque control at all speeds, while providing the most accurate speed regulation of all torque control algorithms. Use A044=05 to select sensorless vector control with feedback.

These three control algorithms require the inverter's motor constants to accurately match the characteristics of the particular motor connected to your inverter. Simply using the inverter's default parameters with the vector control modes may not produce satisfactory results. The auto-tuning procedure described later in this section is recommended for most applications needing vector control. It determines and records the characteristics of the attached motor. However, it is possible to enter the motor constants directly if the motor manufacturer has provided that data.

After performing an initial auto-tuning procedure for your motor, you have an additional option: adaptive tuning. The adaptive tuning parameters use the auto-tuning procedure's results as starting values. Then, each time the motor runs normally in your application, the inverter tunes the parameters again to match the motor. This compensates for temperature changes, etc., further optimizing the values.

The following table lists the parameters associated with motor constant settings. Function H002 selects the set of motor constants that you want the inverter to use in normal use. Standard constants (select with H002=00) include H020 to H024. Auto-tuned constants (select with H002=01) include H030 to H034. Remember that you have to do the auto-tuning procedure in this section before using either auto-tuned constants or the adaptive mode (H002=02).

Func.	Name	Data	Notes
A044 / A244 / A344	V/f characteristic curve selection, 1st / 2nd / 3rd motors	00	V/f constant torque
		01	V/f variable torque
		02	V/f free-setting curve
		03	Sensorless vector control (SLV)
		04	Sensorless vector control, 0Hz domain
		05	Vector control with encoder feedback
H002	Motor data selection, 1st motor	00	Standard motor parameters
		01	Auto-tuning parameters
		02	Adaptive tuning parameters
H003	Motor capacity, 1st motor	0.2 – 75, 0.2 – 160	kW, up to –550xxx models kW, –750xxx to –1500xxx models
H004	Motor poles setting, 1st motor	2 / 4 / 6 / 8	Units: poles
H020	Motor constant R1, 1st motor	0.000–65.53	Units: ohms
H021	Motor constant R2, 1st motor	0.000–65.53	Units: ohms
H022	Motor constant L, 1st motor	0.00–655.3	Units: mH
H023	Motor constant Io, 1st motor	0.00–655.3	Units: A
H024	Motor constant J, 1st motor	0.001–9999	Units: kgm^2
H030	Auto-tuned constant R1, 1st motor	0.000–65.53	Units: ohms

Func.	Name	Data	Notes
H031	Auto-tuned constant R2, 1st motor	0.000–65.53	Units: ohms
H032	Auto-tuned constant L, 1st motor	0.00–655.3	Units: mH
H033	Auto-tuned constant Io, 1st motor	0.00–655.3	Units: A
H034	Auto-tuned constant J, 1st motor	0.001–9999	Units: kgm^2

The inverter has three separate motor constant sets named *1st*, *2nd*, and *3rd*. The 1st motor constant set is the default, while the SET and SET2 intelligent inputs select the 2nd and 3rd constant sets, respectively. The torque control methods are valid to use only if a particular motor constant set includes parameters for the selected control method. The following table lists the vector control methods and shows the ones that are valid for each motor constant set.:

Vector Control Method	1st motor	2nd motor	3rd motor
V/f constant torque	✔	✔	✔
V/f variable torque	✔	✔	✔
V/f free-setting curve	✔	✔	✘
Sensorless vector control (SLV)	✔	✔	✘
Sensorless vector control, 0Hz domain	✔	✔	✘
Vector control with encoder feedback	✔	✘	✘

The motor data selection is available only to the 1st motor constant set, selected by function H004. By default, the 2nd and 3rd motor constants sets only store standard motor parameters. The table below shows this arrangement.

Motor data selection	1st motor	2nd motor	3rd motor
Standard motor parameters	✔	✔	✔
Auto-tuning parameters	✔	✘	✘
Adaptive tuning parameters	✔	✘	✘

When motor constant values are available from the motor manufacturer, you can enter them directly. The available motor constant parameters (storage locations) depend on the motor constant set (1st, 2nd, or 3rd) according to the following table.

Motor data selection	1st motor	2nd motor	3rd motor
Standard motor parameters	H020 to H024	H220 to H224	—
Auto-tuning parameters	H030 to H034	—	—
Adaptive tuning parameters	H030 to H034	—	—

Auto-tuning of Motor Constants

The SJ300 inverter features auto-tuning, which detects and records the motor characteristic parameters to use in all vector control modes. Auto-tuning determines the resistance and inductance of motor windings. Therefore, the motor must be connected to the inverter for this procedure. Note that the auto-tuning feature is not associated with PID loop operation, which is common on some control devices. The auto-tuning procedure must be conducted while the inverter is stopped (not in Run mode), so it can use special output pulses to detect motor characteristics.

When using the inverter in sensorless vector control, sensorless vector control - 0Hz domain, or vector control with encoder feedback, the motor circuit constants are important. If they are unknown, then you must first conduct the auto-tuning procedure. The inverter will determine the constants and write new values for the related “H” Group settings. The auto-tuning procedure requires that the inverter be configured to operate the 1st motor (do not set the inverter to use 2nd and 3rd motor data during an auto-tuning procedure).

Func.	Name	Range	Notes
H001	Auto-tuning setting	00	Disabled
		01	Enabled, without motor rotation
		02	Enabled, with motor rotation
H002	Motor data selection, 1st motor	00	Standard motor parameters
		01	Auto-tuning parameters
		02	Adaptive tuning parameters
H003	Motor capacity, 1st motor	0.2 – 75, 0.2 – 160	kW, up to –550xxx models kW, –750xxx to –1500xxx models
H004	Motor poles setting, 1st motor	2 / 4 / 6 / 8	Units: poles
H030	Auto-tuned motor constant R1, 1st motor	—	Units: ohms
H031	Auto-tuned motor constant R2, 1st motor	—	Units: ohms
H032	Auto-tuned motor constant L, 1st motor	—	Units: mH
H033	Auto-tuned motor constant Io, 1st motor	—	Units: A
H034	Auto-tuned motor constant J, 1st motor	—	Units: kgm^2
A003	Base frequency setting	30 to maximum freq.	Units: Hz
A051	DC braking enable	00	Disabled (Disable during auto-tuning)
		01	Enabled
A082	AVR voltage select	200/215/220/230/240	Valid for 200V class inverters
		380/400/415/440/460/480	Valid for 400V class inverters

Please read the following Warning before running the auto-tuning procedure on the next page.

WARNING: You may need to disconnect the load from the motor before performing auto-tuning. The inverter runs the motor forward and backward for several seconds without regard to load movement limits.

Preparation for Auto-tuning Procedure – Be sure to study the preparation items and verify the related inverter configuration before going further in this procedure.

1. Adjust the motor base frequency (A003) and the motor voltage selection (A082) to match the specifications of the motor used in the auto-tuning procedure.
2. Verify that the motor is not more than one frame size smaller than the rated size for he inverter. Otherwise, the motor characteristic measurements may be inaccurate.
3. Be sure that no outside force will drive the motor during auto-tuning.
4. If DC braking is enabled (A051=01), the motor constants will not be accurately set. Therefore, disable DC braking (A051=00) before starting the auto-tuning procedure.
5. When auto-tuning with motor rotation (H002=02), take care to verify the following points:
   - **a.** The motor will rotate up to 80% of the base frequency; make sure that this will not cause any problem.
   - **b.** Do not attempt to either run or stop the motor during the auto-tuning procedure unless it is an emergency. If this occurs, initialize the inverter's parameters to the factory default settings (see "Restoring Factory Default Settings" on page 6–9). Then reprogram the parameters unique to your application, and initiate the auto-tuning procedure again.
   - **c.** Release any mechanical brake that would interfere with the motor rotating freely.
   - **d.** Disconnect any mechanical load from the motor. The torque during auto-tuning is not enough to move some loads.
   - **e.** If the motor is part of a mechanism with limited travel (such as lead screw or elevator), select H001=01 so that the auto-tuning will not cause motor rotation.
6. Note that even when you select H001=01 for no rotation, sometimes the motor will rotate.
7. When using a motor that is one frame size smaller than the inverter rating, enable the overload restriction function. Then set the overload restriction level to 1.5 times the rated output current of the motor.

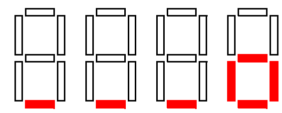
Auto-tuning Procedure

After the preparations above are complete, perform the auto-tuning procedure by following the steps below.

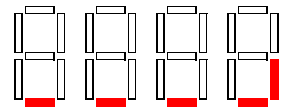
1. Set H001=01 (auto-tuning *without* motor rotation) or H001=02 (auto-tuning *with* motor rotation).
2. Turn the Run command ON. The inverter will then automatically sequence through the following actions:
   - **a.** First AC excitation (motor does not rotate)
   - **b.** Second AC excitation (motor does not rotate)
   - **c.** First DC excitation (motor does not rotate)
   - **d.** V/F running—this step occurs only if H001=02 (motor accelerates up to 80% of the base frequency)
   - **e.** SLV running—this step occurs only if H001=02 (motor accelerates up to x% of the base frequency), where "x" varies with time T during this step:
x=40% when T < 50s
x=20% when 50s < T < 100s
x=10% when T => 100s
   - **f.** Second DC excitation
   - **g.** Displays the pass/fail result of the auto-tuning (see next page)

NOTE: During the AC and DC motor excitation steps above, you may notice that the motor makes a slight humming sound. This sound is normal.

If the auto-tuning procedure is successful, the inverter updates the motor characteristic parameters and indicates *normal termination* of the procedure as shown. Pressing any key on the keypad will clear the result from the display.



Normal termination



Abnormal termination

- **Trip during auto-tuning –** A trip event will cause the auto-tuning sequence to quit. The display will show the error code for the trip rather than the abnormal termination indication. After eliminating the cause of the trip, then conduct the auto-tuning procedure again.
- **Power loss or stop during auto-tuning –** If the auto-tuning procedure is interrupted by power loss, the Stop key, or by turning OFF the Run command, the auto-tuning constants may or may not be stored in the inverter. It will be necessary to restore the inverter's factory default settings (see "Restoring Factory Default Settings" on page 6–9). After initializing the inverter, then perform the auto-tuning procedure again.
- **Free V/F setting –** The auto-tuning procedure will have an abnormal termination if the control mode of the inverter is set for free V/F setting.

Adaptive Auto-tuning of Motor Constants

The adaptive auto-tuning feature refines the motor constants by checking the motor characteristic while it in the normal running temperature range.

Preparation for Adaptive Auto-tuning – Be sure to study the preparation items and verify the related inverter configuration before going further in this procedure.

1. It is necessary to first perform the auto-tuning procedure in the section above, since adaptive auto-tuning requires accurate initial constant values.
2. Adaptive auto-tuning is valid only for the 1st motor data (do not use 2nd or 3rd motor data settings).
3. The adaptive auto-tuning sequence actually begins as the motor decelerates to a stop from a Run command you initiate. However, the sequence still continues for five (5) more seconds. Giving another Run command during this 5-second time period will halt the adaptive auto-tuning. It will resume the next time the motor runs and decelerates to a stop.
4. If DC braking is enabled, then the adaptive auto-tuning sequence executes after DC braking brings the motor to a stop.

After reading and following the preparation steps above, then configure the inverter for adaptive auto-tuning by following these steps:

1. Set H002=02 for adaptive auto-tuning procedure
2. Set H001=00 to disable the (manual) auto-tuning procedure
3. Turn the Run command ON.
4. Run the motor for an appropriate time until it reaches its normal operating temperature range. Remember that the purpose of adaptive auto-tuning is optimize the inverter for typical running conditions.
5. Stop the motor (or turn the Run command OFF), which initiates an adaptive auto-tuning. Wait at least five (5) seconds before issuing any other command to the inverter.

With the above configuration, the inverter automatically runs the adaptive auto-tuning sequence each time the motor runs and decelerates to a stop. This continuously adapts the SLV control algorithm to slight changes in the motor constants during operation.

NOTE: It is not necessary to wait 5 seconds after each time the motor runs before running again. When the motor stops for less than 5 seconds before running again, the inverter stops the adaptive tuning sequence and keeps the current motor constant values in memory. The inverter will attempt the adaptive auto-tuning at the next run/stop event of the motor.

Manual Setting of Motor Constants

With vector control, the inverter uses the output current, output voltage, and motor constants to estimate the motor torque and speed. It is possible to achieve a high starting torque and accurate speed control at low frequency

- **Sensorless Vector Control –** improved torque control at output frequencies down to 0.5 Hz. Use A044=03 (1st motor) or A244=03 (2nd motor) to select sensorless vector control.
- **Sensorless Vector Control, 0Hz Domain –** improved torque control at output frequencies from 0 to 2.5 Hz. Use A044=04 (1st motor) or A244=04 (2nd motor). For this vector control method, we recommend using a motor that is one frame size smaller than the inverter size.
- **Sensorless Vector Control with Feedback –** improved torque control at all speeds, while providing the most accurate speed regulation

If you do use any vector control methods, it is important that the motor constants stored in the inverter match the motor. We recommend first using the auto-tuning procedure in the previous section. If satisfactory performance through auto-tuning cannot be fully obtained, please adjust the motor constants for the observed symptoms according to the table below.

CAUTION: If the inverter capacity is more than twice the capacity of the motor in use, the inverter may not achieve its full performance specifications.

CAUTION: You must use a carrier frequency of more than 2.1kHz. The inverter cannot operate in vector control mode at less than 2.1 kHz carrier frequency.

Operation Status	Symptom	Adjustment	Parameter
Powered running	When the speed deviation is negative	Slowly increase the motor constant R2 in relation to auto-tuning data, within 1 to 1.2 times preset R2	H021 / H221
	When the speed deviation is positive	Slowly decrease the motor constant R2 in relation to auto-tuning data, within 0.8 to 1 times preset R2	H021 / H221
Regeneration (status with a decel-erating torque)	When low frequency (a few Hz) torque is insuffi-cient	Slowly increase the motor speed constant R1 in relation to auto-tuning data within 1 to 1.2 times R1	H020 / H220
		Slowly increase the motor constant IO in relation to auto-tuning data, within 1 to 1.2 times preset IO	H023 / H223
During acceleration	A sudden jerk at start of rotation	Increase motor constant J slowly within 1 to 1.2 times the preset constant	H024 / H224
During deceleration	Unstable motor rotation	Decrease the speed response	H05, H205
		Set motor constant J smaller than the preset constant	H024, H224
During torque limiting	Insufficient torque during torque limit at low speed	Set the overload restriction level lower than the torque limit level	B021, B041 to B044
At low-frequency operation	Irregular rotation	Set motor constant J larger than the preset constant	H024, H244

When using a motor one frame size smaller than the inverter rating, the torque limit value (B041 to B044) is from the following formula and the value of the actual motor torque limit is calculated by the formula. Do not set a value in B041 to B044 that results in an actual torque greater than 200% or you risk motor failure.

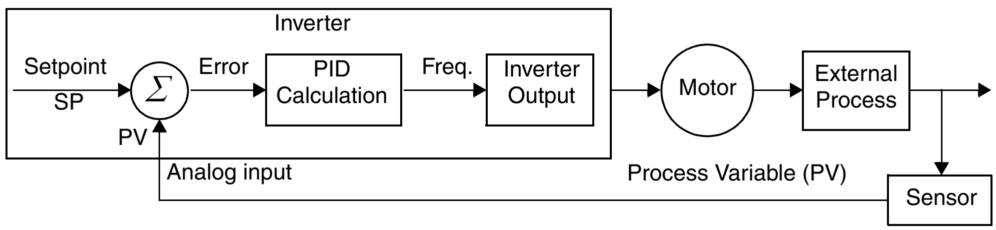
For example, suppose you have a 0.75kW inverter and a 0.4kW motor. The torque limit setting value that is for T=200% is set (entered) as 106%, shown by the following formula:

$$\text{Torque limit setting} = \frac{\text{Actual torque limit} \times \text{Motor capacity}}{\text{Inverter capacity}} = \frac{200\% \times 0.4\text{kW}}{0.75\text{kW}} = 106\%$$

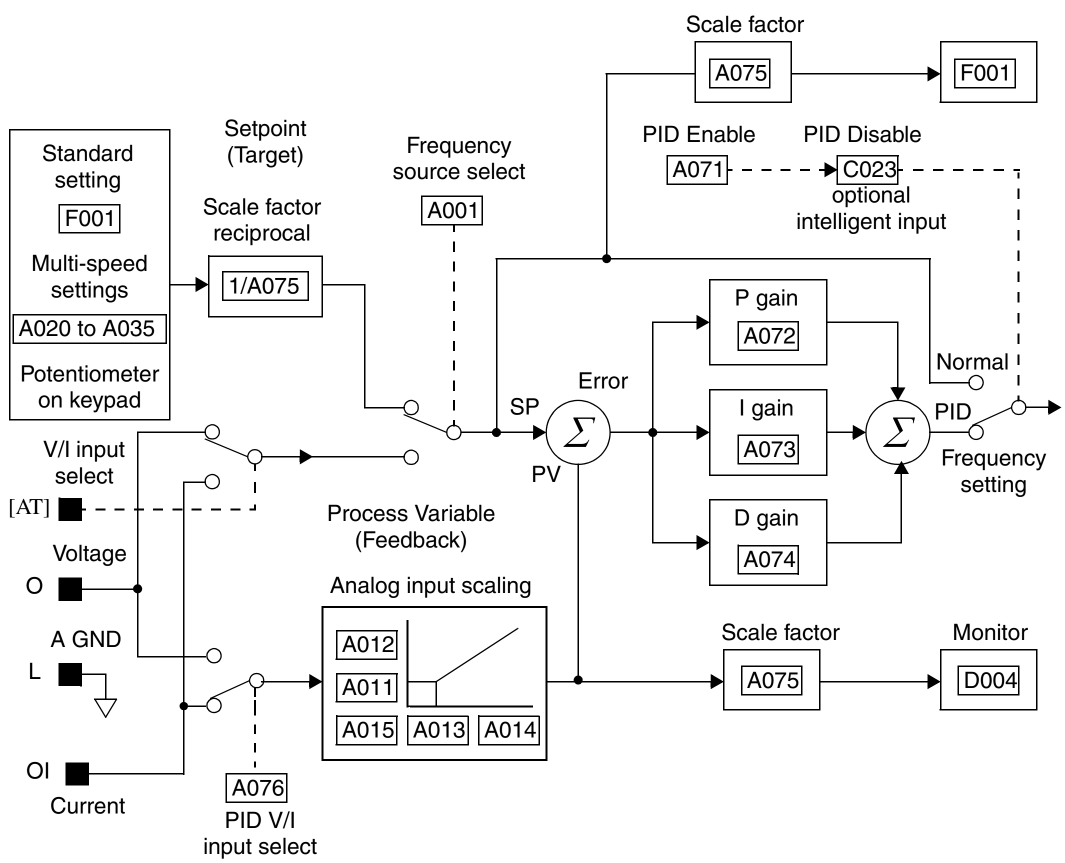
PID Loop Operation

In standard operation, the inverter uses a reference source selected by parameter A001 for the output frequency, which may be a fixed value (F001), a variable set by the front panel potentiometer, or value from an analog input (voltage or current). To enable PID operation, set A071 = 01. This causes the inverter to *calculate* the target frequency, or setpoint. An optional intelligent input assignment (code 23), PID Disable, will temporarily disable PID operation when active.

A calculated target frequency can have a lot of advantages. It lets the inverter adjust the motor speed to optimize some other process variable of interest, potentially saving energy as well. Refer to the figure below. The motor acts upon the external process. To control that external process, the inverter must monitor the process variable. This requires wiring a sensor to either the analog input terminal [O] (voltage) or terminal [OI] (current).



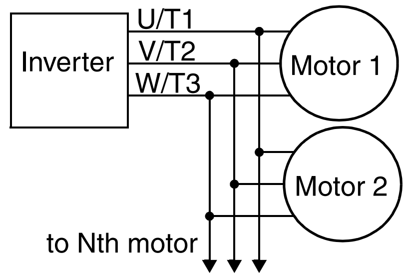
When enabled, the PID loop calculates the ideal output frequency to minimize the loop error. This means we no longer command the inverter to run at a particular frequency, but we specify the ideal value for the process variable. That ideal value is called the *setpoint*, and is specified in the units of the external process variable. For a pump application it may be gallons/minute, or it could be air velocity or temperature for an HVAC unit. Parameter A075 is a scale factor that relates the external process variable units to motor frequency. The figure below is a more detailed diagram of the PID function.



Configuring the Inverter for Multiple Motors

Simultaneous Connections

For some applications, you may need to connect two or more motors (wired in parallel) to a single inverter's output. For example, this is common in conveyor applications where two separate conveyors need to have approximately the same speed. The use of two motors may be less expensive than making the mechanical link for one motor to drive multiple conveyors.



Some of the requirements when using multiple motors with one drive are:

- Use only V/F (variable-frequency) control; do not use SLV (sensorless vector control).
- The inverter output must be rated to handle the sum of the currents from the motors.
- You must use separate thermal protection switches or devices to protect each motor. Locate the device for each motor inside the motor housing or as close to it as possible.
- The wiring for the motors must be permanently connected in parallel (do not remove one motor from the circuit during operation).

NOTE: The motor speeds are identical only in theory. That is because slight differences in their loads will cause one motor to slip a little more than another, even if the motors are identical. Therefore, do not use this technique for multi-axis machinery that must maintain a fixed position reference between its axes.

Inverter Configuration for Multiple Motor Types

Some equipment manufacturers may have a single type of machine that has to support three different motor types—and only one motor will be connected at a time. For example, an OEM may sell basically the same machine to the US market and the European market. Some reasons why the OEM needs two motor profiles are:

- The inverter power input voltage is different for these markets.
- The required motor type is also different for each destination.

In other cases, the inverter needs two profiles because the machine characteristics vary according to these situations:

- Sometimes the motor load is very light and can move fast. Other times the motor load is heavy and must move slower. Using two profiles allows the motor speed, acceleration and deceleration to be optimal for the load and avoid inverter trip (fault) events.
- Sometimes the slower version of the machine does not have special braking options, but a higher performance version does have braking features.

Having multiple motor profiles lets you store several "personalities" for motors in one inverter's memory. The inverter allows the final selection between the three motor types to be made in the field through the use of intelligent input terminal functions [SET] and [SET3]. This provides an extra level of flexibility needed in particular situations. See the following page.

Parameters for the second motor and third motors have function codes of the form x2xx and x3xx respectively. They appear immediately after the first motor's parameter in the menu listing order. The following table lists the parameters that have the second/third parameter registers for programming.

Function Name	Parameter Codes		
	1st motor	2nd motor	3rd motor
Multi-speed frequency setting	A020	A220	A320
Acceleration time setting (Acceleration 1)	F002	F202	F302
Deceleration time setting (Deceleration 1)	F003	F203	F303
Second acceleration time setting (Acceleration 2)	A092	A292	A392
Second deceleration time setting (Deceleration 2)	A093	A293	A393
Select method to use 2nd acceleration/deceleration	A094	A294	—
Acc1 to Acc2 frequency transition point	A095	A295	—
Dec1 to Dec2 frequency transition point	A096	A296	—
Level of electronic thermal setting	B012	B212	B312
Select electronic thermal characteristic	B013	B213	B313
Torque boost method selection	A041	A241	—
Manual torque boost value	A042	A242	—
Manual torque boost frequency adjustment	A043	A243	A343
V/F characteristic curve selection	A044	A244	A344
Base frequency setting	A003	A203	A303
Maximum frequency setting	A004	A204	A304
Select motor constant	H002	H202	—
Motor capacity setting	H003	H203	—
Motor poles setting	H004	H204	—
Motor constant R1 setting (Standard, Auto tuning)	H020/H030	H220/H230	—
Motor constant R2 setting (Standard, Auto tuning)	H021/H031	H221/H231	—
Motor constant L setting (Standard, Auto tuning)	H022/H032	H222/H232	—
Motor constant Io setting (Standard, Auto tuning)	H023/H033	H223/H233	—
Motor constant J setting (Standard, Auto tuning)	H024/H034	H224/H234	—
Motor constant Kp setting (Standard, Auto tuning)	H005	H205	—
Motor stabilization constant	H006	H206	—